Physical, Chemical and Zooplankton Data from the Canada Basin and Canadian Arctic Archipelago, July 29 to September 1, 2005

F. McLaughlin, A. Proshutinsky, E.C. Carmack, K. Shimada, M. Corkum, J. Eert, C. Guay, R. Krishfield, B. Li, H. Maclean, J. Nelson, W. Richardson, D. Sieberg, J. Smith, M. Steel, N. Sutherland, W. Walczowski, L. White, M. Yamamoto-Kawai and S. Zimmermann

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Science Branch, Pacific Region
Institute of Ocean Sciences
9860 West Saanich Road
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2010

Canadian Data Report of Hydrography and Ocean Sciences 185

Fisheries and Oceans Canada Pêches et Océans Canada

Canada

Canadian Data Report of Hydrography and Ocean Sciences

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Rapport statistique canadien sur l'hydrographie et les sciences océaniques

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Canadian Data Report of
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PHYSICAL, CHEMICAL AND ZOOPLANKTON DATA FROM THE CANADA BASIN AND CANADIAN ARCTIC ARCHIPELAGO, JULY 29 TO SEPTEMBER 1, 2005

by

F. McLaughlin, A. Proshutinsky, E.C. Carmack, K. Shimada,
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Abstract

McLaughlin, F., Proshutinsky, A., Carmack, E.C., Shimada, K., Corkum, M., Eert, J., Guay, C., Krishfield, R., Li, B., Maclean, H., Nelson, J., Richardson, W., Sieberg, D., Smith, J., Steel, M., Sutherland, N., Walczowski, W., White, L., Yamamoto-Kawai, M. and Zimmermann, S. 2010. Physical, chemical and zooplankton data from the Canada Basin and Canadian Arctic Archipelago, July 29 to September 1, 2005. *Can. Data Rep.Hydrogr. Ocean Sci.* 185: ix + 298 p.

A hydrographic survey of the Arctic Ocean's Canada Basin was conducted during a Joint Ocean Ice Study (JOIS) expedition aboard the *CCGS Louis S. St-Laurent* from 29 July to 1 September, 2005 (Institute of Ocean Sciences Mission Number 2005-04). The objective of the program was to investigate ocean circulation, Pacific and Atlantic-origin water mass distributions, storage of freshwater in the Beaufort Gyre, inter-annual variability and the distribution and concentration of bacteria and zooplankton. This report provides a summary of all science activities conducted during the cruise and includes data collected from CTD/rosette casts. The CTD consists of pressure, temperature, salinity, oxygen, transmission and fluorescence sensor data and the rosette bottle data include salinity, dissolved oxygen, nutrients, oxygen isotope ratio, barium, dissolved inorganic carbon, alkalinity, chlorophyll-a and phaeopigment, bacteria, iodine and cesium radionuclides, halocarbons including CFCs, and total organic carbon. Sample collection and analytical methods are described. Other samples collected during the expedition, not reported here, are also listed.

Résumé

McLaughlin, F., Proshutinsky, A., Carmack, E.C., Shimada, K., Corkum, M., Eert, J., Guay, C., Krishfield, R., Li, B., Maclean, H., Nelson, J., Richardson, W., Sieberg, D., Smith, J., Steel, M., Sutherland, N., Walczowski, W., White, L., Yamamoto-Kawai, M. and Zimmermann, S. 2010. Physical, chemical and zooplankton data from the Canada Basin and Canadian Arctic Archipelago, July 29 to September 1, 2005. *Can. Data Rep.Hydrogr. Ocean Sci.* 185: ix + 298 p.

Une enquête hydrographique de l'eau du bassin Canada, dans l'océan Arctique, ont été évaluées lors d'une expédition menée dans le cadre des Études conjointes sur les glaces (JOIS) à bord du NGCC *Louis S. St-Laurent*, du 29 juillet au 1 septembre 2005 (mission numéro 2005-04 de l'Institut des sciences de la mer). L'objet du programme était d'étudier les mouvements de circulation océaniques, notamment la distribution des masses d'eau d'origine atlantique et pacifique, les réserves d'eau douce de la gyre de Beaufort, les variabilités interannuelles et la distribution/concentration de bactéries et de zooplancton. Ce rapport présente un sommaire de toutes les activités scientifiques ainsi que les données des profils de conductivité-température-profondeur(CTP)/Rosette. Les données de CTP informent sur la pression, la température, la salinité et la teneur en oxygène, alors que les données captées par transmission et fluorescence et les données de bouteille (données recueillies dans des échantillons d'eau) touchent la salinité ainsi que la teneur en oxygène, en nutriments, le ratio des isotopes de l'oxygène, en baryum, en carbone inorganique dissous, l'alcalinité, en chlorophylle *a* et en phaéopigments, des bactéries, en radionucléides de l'iode et du césium, halocarbures, y compris les CFS et en carbone organique total. Les méthodes d'échantillonnage et d'analyse sont décrites. D'autres échantillons prélevés au cours de l'expédition mais non traités dans ce rapport sont également mentionnés.

Acknowledgements

We would like to thank Captain Potts, Captain McNeill and the crews of the *CCGS Louis S. St-Laurent* for all the work and help they put into this trip and its preparation. A special thanks to Chief Engineer Ron Collier and the engineering department for the impressive emergency at-sea repairs performed. In addition we would like to thank the Canadian Ice Service for their support with ice and weather information, the Coast Guard for altering the timing of the crew change, and the *CGCS Sir Wilfrid Laurier* for transferring equipment and samples back to the Institute of Ocean Sciences.

This work was supported by Fisheries & Oceans Canada in collaboration with scientists from the Japan Agency for Marine-Earth Science and Technology and Woods Hole Oceanographic Institution. A portion of the costs of the JWACS cruise and hydrographic station data, and the BGFE mooring and buoy installations was provided by NSF grant number OPP-0424864 – "The Beaufort Gyre System: Flywheel of the Arctic Climate?"; A. Proshutinsky, Principal Investigator. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the National Science Foundation.

1. INTRODUCTION

The Joint Ocean Ice Study (JOIS) is a collaboration between DFO researchers from the Institute of Ocean Sciences (IOS) and colleagues from Japan and the U.S. It combines two ongoing programs: the Joint Western Arctic Climate Study (JWACS), a collaboration with scientists from the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) to conduct oceanographic surveys; and the Beaufort Gyre Exploration Project (BGEP), a collaboration with scientists from Woods Hole Oceanographic Institution (WHOI) in the U.S. to deploy and service moorings and buoys. The four primary investigators are Fiona McLaughlin (DFO), Eddy Carmack (DFO), Andrey Proshutinsky (WHOI) and Koji Shimada (JAMSTEC).

The JOIS-2005 study area was the Arctic Ocean's southern Canada Basin, and the survey extended as far north as 79°N. The program objective was to study the effects of climate variability and the relationships between the physical environment and biota across shelf break, slope and basin domains. Specifically, the objectives were:

- To understand the impacts of global climate change on the physical environment by linking decadal scale perturbations in the Arctic atmosphere (e.g. Arctic Oscillation and Beaufort Gyre) to interannual basin-scale changes in water mass properties and circulation.
- To understand the impacts of global climate change on sea ice and other fresh water products by utilizing a suite of stable isotopes and geochemical markers to quantify freshwater into their meteoric and sea ice components.
- To investigate water mass modification due to processes such as convection and primary production with a suite of geochemical tracers.
- To understand the impacts of global climate change on the distribution of biota by investigating distributions and abundances of bacteria and zooplankton.

The program was conducted aboard the *CCGS Louis S. St-Laurent* from 29 July to 1 September, 2005 (IOS Mission Number 2005-04). A science team of 18 people (**Appendix 1**) conducted Conductivity, Temperature and Depth (CTD) rosette casts, mooring recovery and deployments, expendable CTD (XCTD) casts and vertical net tow operations. A high resolution, full ocean-depth hydrographic survey of the southern Canada Basin was obtained.

This report provides a summary of all science activities and data collected from CTD/rosette casts: the CTD data include pressure, temperature, salinity, oxygen, transmission and fluorescence sensor data; and the rosette bottle data include salinity, dissolved oxygen, nutrients including nitrate plus nitrite (hereafter referred to as nitrate), reactive silicate (hereafter referred to as silicate), orthophosphate (hereafter referred to as phosphate), oxygen isotope ratio ($\delta^{18}O$), barium, dissolved inorganic carbon (DIC), alkalinity, chlorophyll-a and phaeopigment, bacteria, iodine and cesium radionuclides (^{129}I and ^{137}Cs), halocarbons (CFC-11, CFC-12, CFC-113, CCl_4), and total organic carbon (TOC). Sample collection procedures and analytical methods for the CTD rosette water chemistry program, conducted primarily by the team from IOS, are also reported. Other samples collected but not included in this report are colored dissolved organic matter (CDOM) and Carbon-13 isotope (^{13}C). Samples for salinity, dissolved oxygen, nutrients, δ^{18}O, barium, alkalinity (FW), chlorophyll-a and phaeopigment, bacteria and ^{13}C were collected at every station, samples for halocarbons were collected at most stations and DIC, radionuclides, TOC, CDOM and ammonium were collected at select stations.

Note: Contamination compromised ammonium analysis and data are not reported; CDOM samples were compromised during storage and therefore not analyzed; ^{13}C samples have not been analyzed to date (January 2010).

1.1 FIELD WORK SUMMARY

The main science program was conducted in the Beaufort Sea and Canada Basin. Science was also conducted opportunistically in Davis Strait, Baffin Bay and the Canadian Arctic Archipelago during the transit of the ship from its home port in Dartmouth, NS to Cambridge Bay, NU. Mission #2005-04 accomplishments are summarized below and data included in this report are outlined below in **bold font**. Specific location and time of events are listed in the **Appendix 2**.

Transit from Dartmouth, NS to Resolute, NU:

- 30 XCTDs were deployed

Transit through the Canadian Archipelago (1570 km)
29 July to 1 August, 2005, Resolute, NU to Cambridge Bay, NU

- **5 CTD/Rosette casts** from Barrow Strait to Amundsen Gulf: **salinity, nutrient** and bacteria samples were collected.

Canada Basin Survey (4940 km)
1 August to 1 September, 2005, Cambridge Bay to Kugluktuk, NU

- **40 CTD/Rosette casts and 5 CTD Casts**

1. CTD: The primary CTD (a Seabird SBE911+) was equipped with 2 **temperature** sensors, 2 conductivity sensors (for **salinity**), SBE43 **oxygen** probe, **transmissometer**, **fluorometer**, bottom contact warning and an altimeter.
2. Rosette: Water chemistry samples drawn from the 24 10 L Niskin bottles include **salinity**, **dissolved oxygen**, **nitrate, silicate, phosphate, δ^{18}O, barium, DIC, alkalinity, total chlorophyll-a** and **phaeopigment, bacteria, radionuclides ^{129}I** and **^{137}Cs, halocarbons CFC-11, CFC-12, CFC-113** and **CCl_4**, and **TOC**. Other samples collected but not included in this report are CDOM, ^{13}C and ammonium. Note: Contamination compromised ammonium analysis and data are not reported; CDOM samples were compromised during storage and therefore not analyzed; ^{13}C samples have not been analyzed to date (January 2010).
3. LADCP: Current measurements from a downward looking lowered acoustic doppler current profiler.

- 53 XCTDs

- 3 BGEP moorings recovered and 4 deployed (WHOI) with bottom depths 3825, 3821, 3722, 3510 m.

- 1 Shelf-Break mooring deployed (WHOI) with bottom depth 149 m.

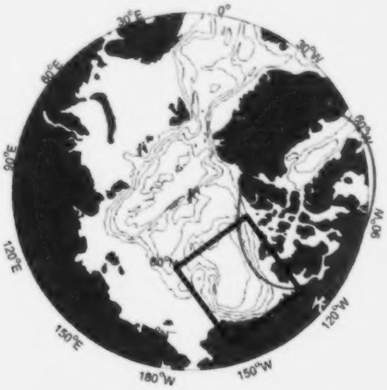
- 1 Canadian Arctic Basin Observing System (CABOS) mooring recovered and deployed for the International Arctic Research Center. Bottom depth 1112 m.

- 2 pairs of buoys deployed consisting of an Ice Tethered Profiler (WHOI) and an Ice Mass Balance Buoy for the Cold Region Research Environmental Lab (CRREL).

- 10 vertical net tows at 4 stations to 100 m; samples were collected with nets having 53 µm, **150 µm** and 236 µm mesh size.

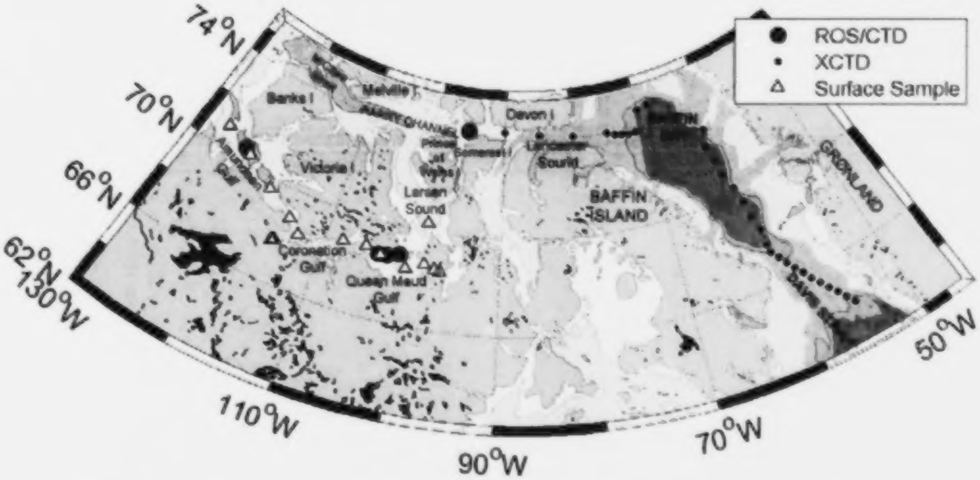
1.2 STUDY AREA

The station locations and accompanying ice conditions are shown in Figures 1 through 6 below. Position information was collected from the ship's GPS. The GPS's NMEA string was fed directly into the cruise track software (Fugawi) and the CTD acquisition software (Seasave by Seabird Inc.). Specific station locations are listed in **Appendix 2**.



0°
30°E
30°W
60°E
60°W
90°E
90°W
120°E
120°W
150°E
150°W
180°W
80°N

Figure 1. View of the Arctic showing Baffin Bay and the Canadian Archipelago in the red circle the Canada Basin in the blue box.



● ROS/CTD
• XCTD
△ Surface Sample
74°N
70°N
66°N
62°N
130°W
110°W
90°W
70°W
50°W
Banks I
Melville I
Amundsen Gulf
Victoria I
Prince of Wales
Somerset I
Devon I
Lancaster Sound
Larsen Sound
Coronation Gulf
Queen Maud Gulf
BAFFIN ISLAND
BAFFIN BAY
GRONLAND
DAVIS ST

Figure 2. Stations in Baffin Bay and the Canadian Archipelago. XCTD and Rosette casts were taken in July; surface samples were collected in September.

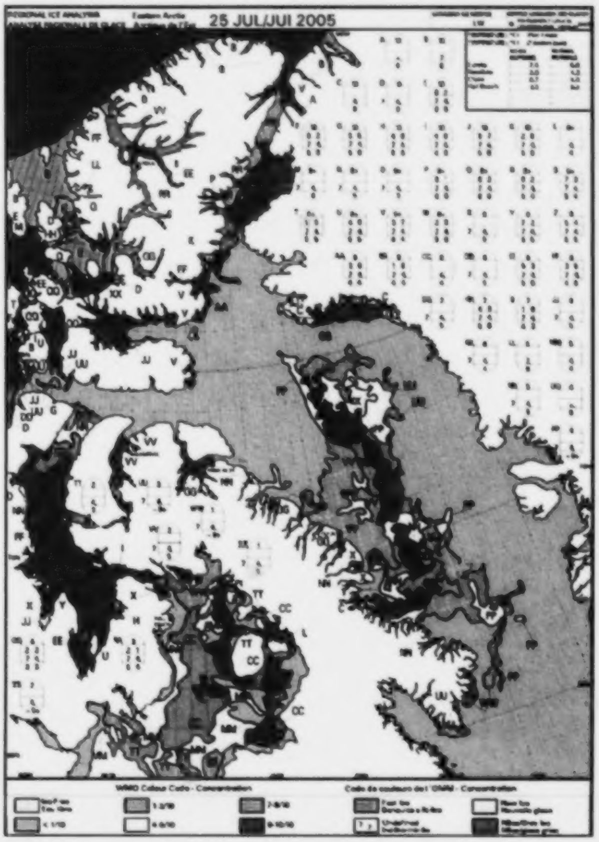


Figure 3. Regional ice analysis by the Canadian Ice Service on July 25, 2005 illustrating conditions during transit through Baffin Bay and the eastern archipelago.

The stations in the Canada Basin are shown in Figure 4. Stations were occupied in a clockwise fashion from south to north along 150°W and from north to south along 140°W, with additional stations in between. This cruise track allowed the ship to work in optimal ice conditions, i.e. to start in the southern ice-free area and then move to the north and east Beaufort when the ice was near the seasonal minimum. Four sections were measured in the Canada Basin, two north-south and two approximately east-west. The four deep BGEP mooring stations are located at the section intersections. XCTDs were deployed between CTD/Rosette stations. Ice conditions at the start and end of the cruise are shown in Figure 5 and Figure 6.

1.2 STUDY AREA

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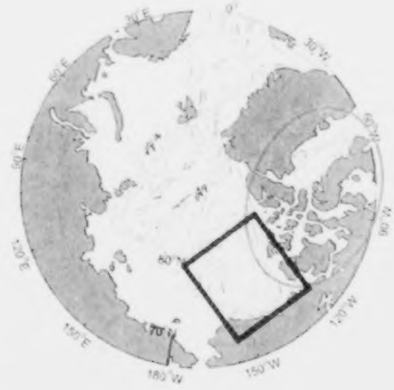

0°
30°W
60°W
90°W
120°W
150°W
180°W
150°E
120°E
90°E
60°E
30°E
80°
70°

Figure 1. View of the Arctic showing Baffin Bay and the Canadian Archipelago in the red circle the Canada Basin in the blue box.

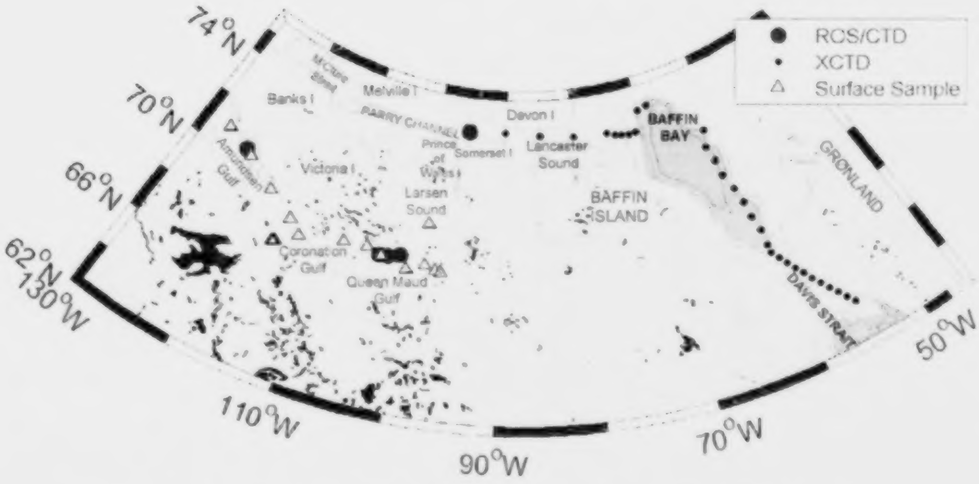
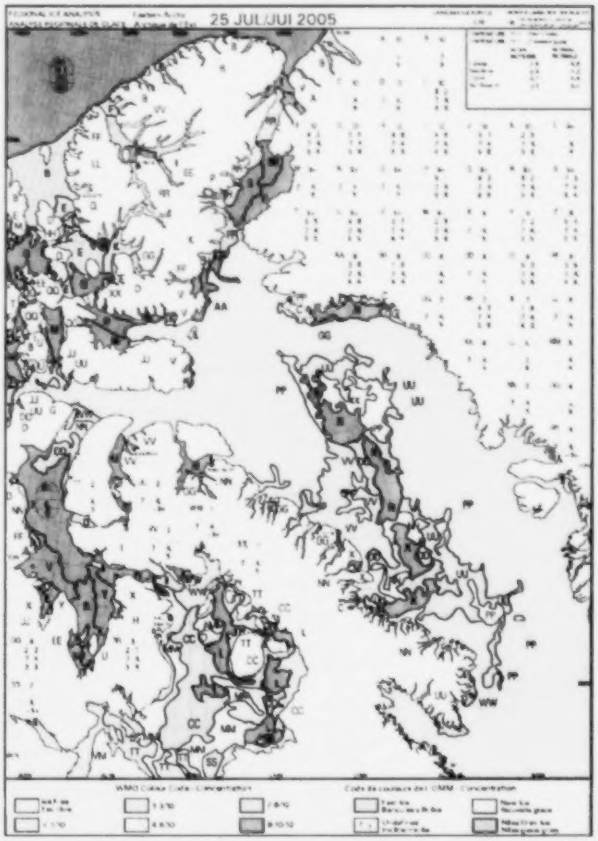

74°N
70°N
66°N
62°N
130°W
110°W
90°W
70°W
50°W
● RCS/CTD
• XCTD
△ Surface Sample
Banks I
M'Clure Strait
Melville I
PARRY CHANNEL
Devon I
Prince of Wales I
Somerset I
Lancaster Sound
BAFFIN BAY
Amundsen Gulf
Victoria I
Larsen Sound
BAFFIN ISLAND
Coronation Gulf
Queen Maud Gulf
GRONLAND
DAVIS STRAIT

Figure 2. Stations in Baffin Bay and the Canadian Archipelago. XCTD and Rosette casts were taken in July; surface samples were collected in September.



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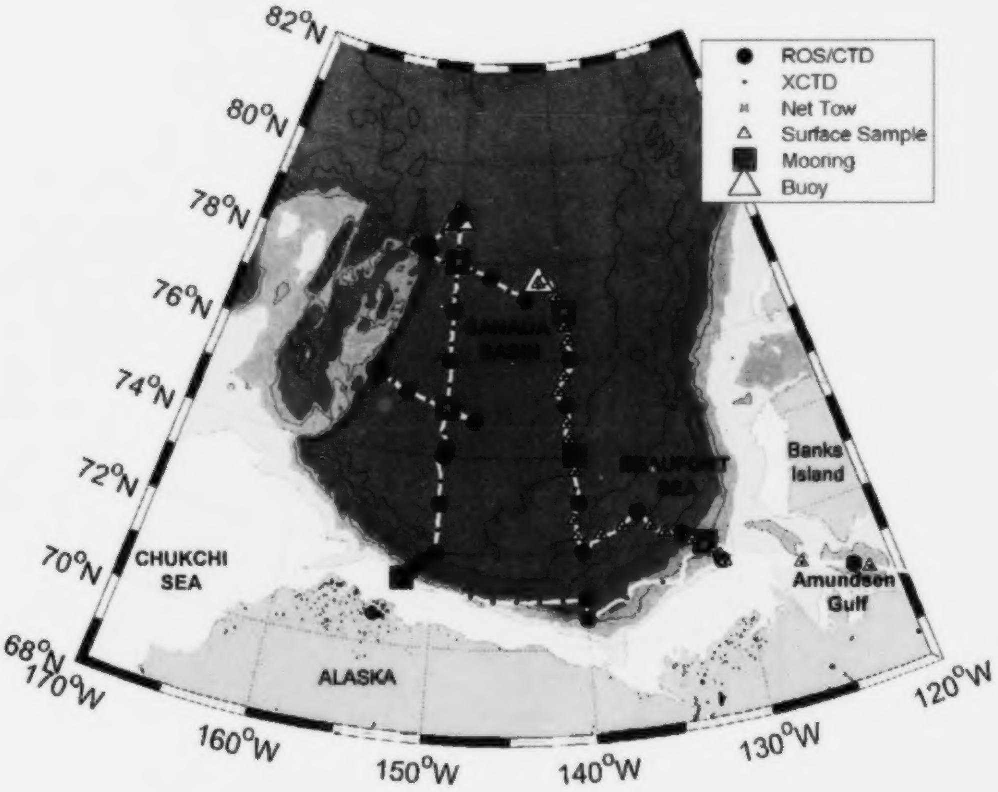

82°N
80°N
78°N
76°N
74°N
72°N
70°N
68°N
170°W
160°W
150°W
140°W
130°W
120°W
● ROS/CTD
• XCTD
x Net Tow
△ Surface Sample
■ Mooring
△ Buoy
CANADA BASIN
BEAUFORT SEA
Banks Island
CHUKCHI SEA
Amundsen Gulf
ALASKA

Figure 4. Cruise track and station locations in the Canada Basin.

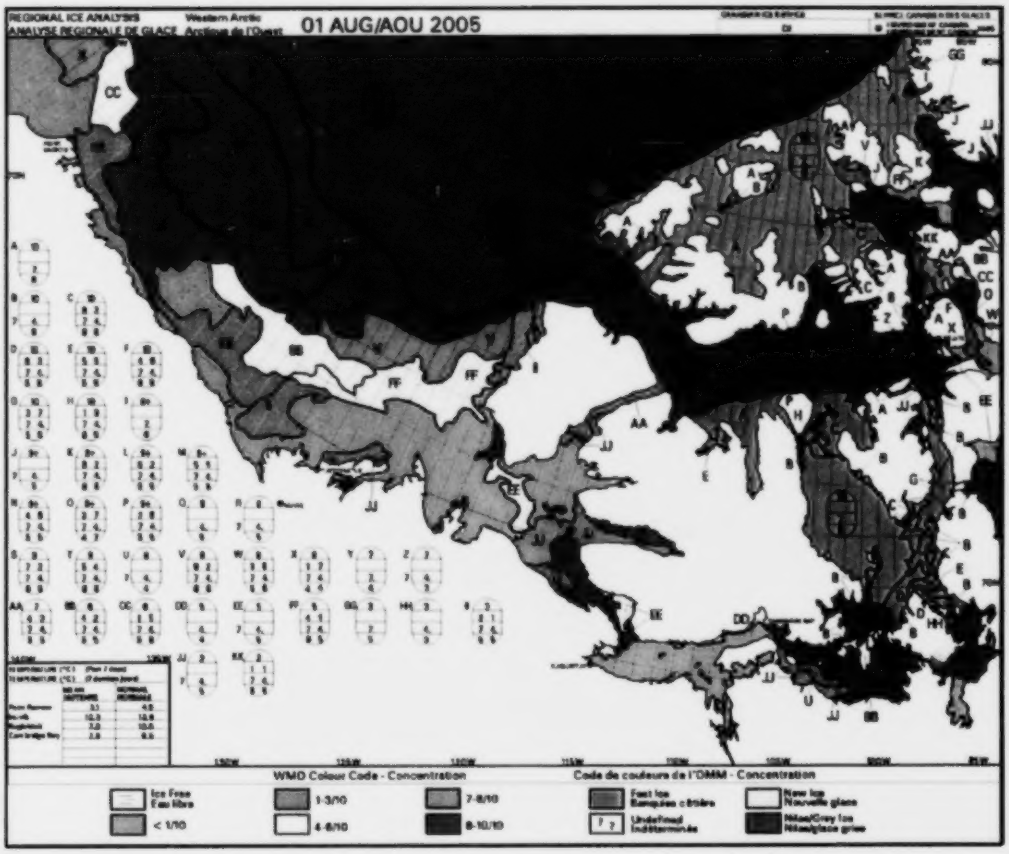
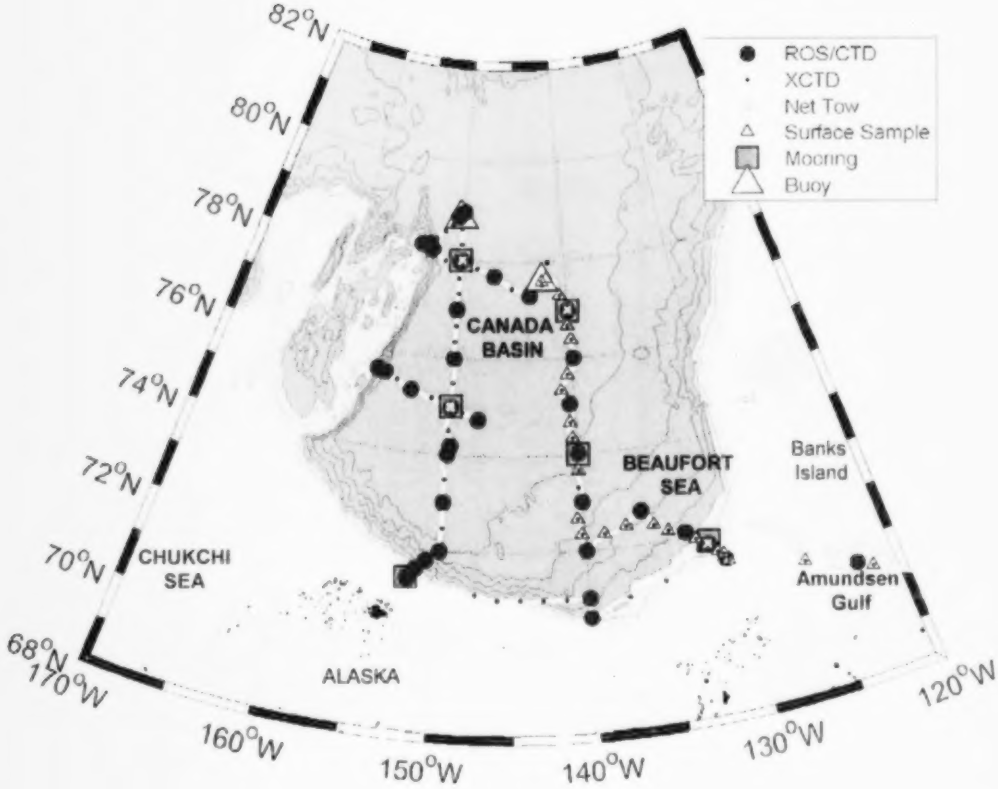

REGIONAL ICE ANALYSIS
ANALYSE REGIONALE DE GLACE
Western Arctic
Arctique de l'Ouest
01 AUG/AOU 2005
WMO Colour Code - Concentration
Code de couleurs de l'OMM - Concentration
Ice Free
Eau libre
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise

Figure 5. Regional ice analysis by the Canadian Ice Service on August 1, 2005, the start of the cruise.


ROS/CTD
XCTD
Net Tow
Surface Sample
Mooring
Buoy
82°N
80°N
78°N
76°N
74°N
72°N
70°N
68°N
170°W
160°W
150°W
140°W
130°W
120°W
CANADA BASIN
BEAUFORT SEA
Banks Island
CHUKCHI SEA
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ALASKA

Figure 4. Cruise track and station locations in the Canada Basin.

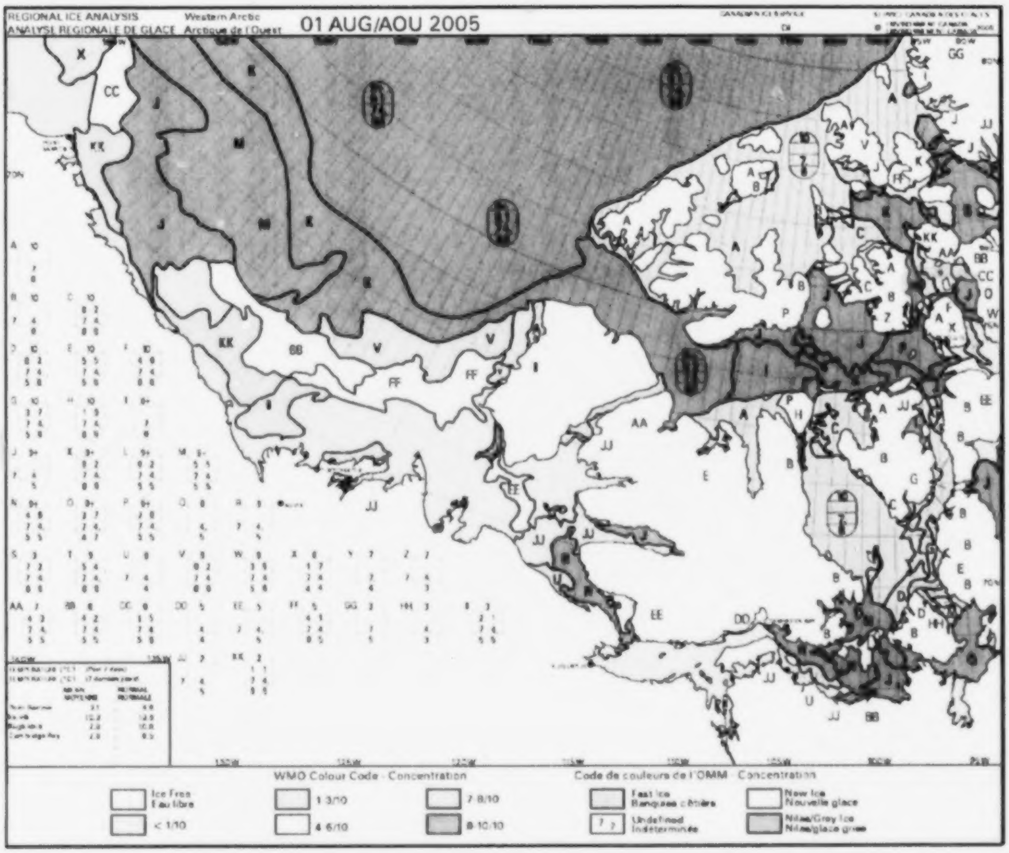
REGIONAL ICE ANALYSIS
ANALYSE REGIONALE DE GLACE
Western Arctic
Arctique de l'Ouest
01 AUG/AOU 2005
WMO Colour Code - Concentration
Code de couleurs de l'OMM - Concentration
Ice Free
Eau libre
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise

Figure 5. Regional ice analysis by the Canadian Ice Service on August 1, 2005, the start of the cruise.

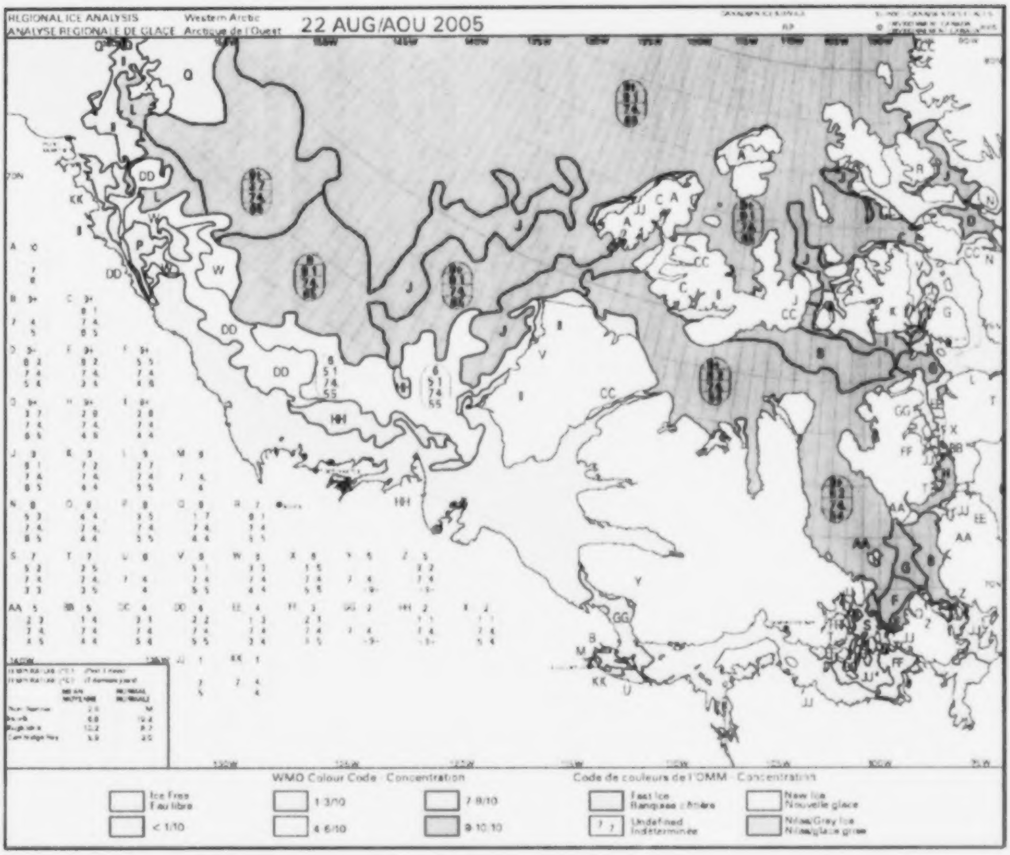
REGIONAL ICE ANALYSIS
ANALYSE REGIONALE DE GLACE
Western Arctic
Arctique de l'Ouest
22 AUG/AOU 2005
WMO Colour Code - Concentration
Code de couleurs de l'OMM - Concentration
Ice Free
Eau libre
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise

Figure 6. Regional ice analysis by the Canadian Ice Service on August 22, 2005, near the end of the cruise.

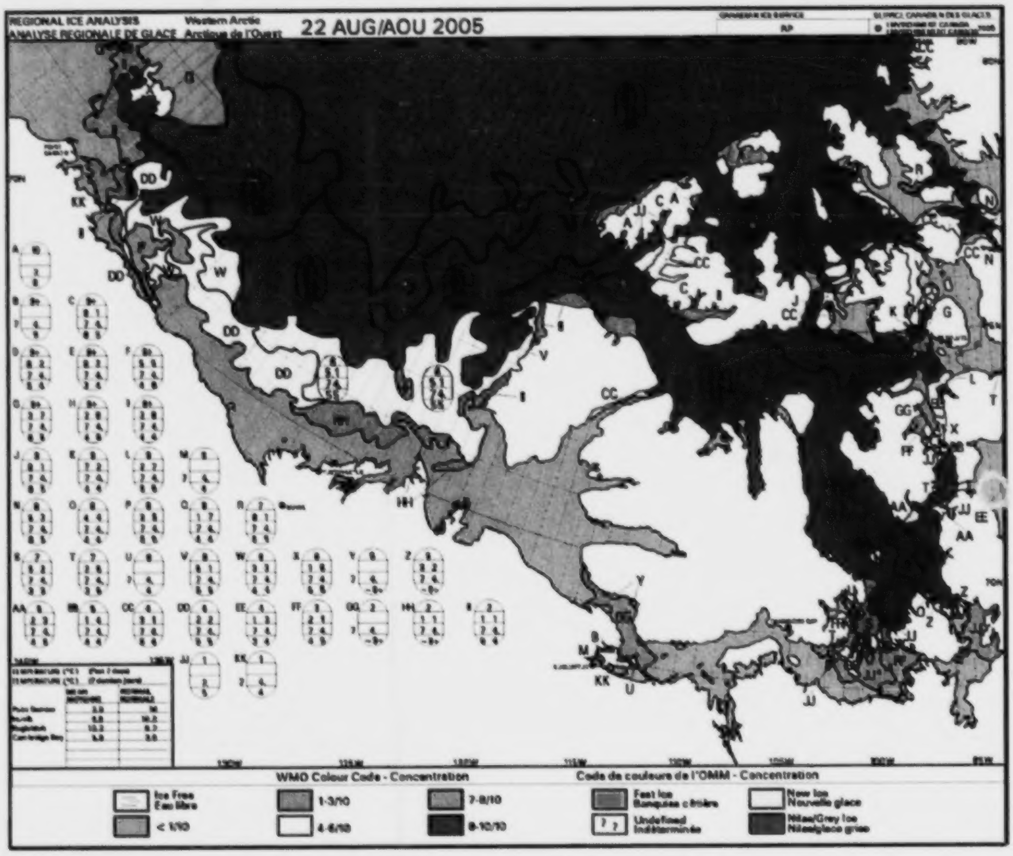
REGIONAL ICE ANALYSIS
ANALYSE REGIONALE DE GLACE
Western Arctic
Arctique de l'Ouest
22 AUG/AOU 2005
WMO Colour Code - Concentration
Code de couleurs de l'OMM - Concentration
Ice Free
Eau libre
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise

Figure 6. Regional ice analysis by the Canadian Ice Service on August 22, 2005, near the end of the cruise.

2. METHODS AND ANALYSIS

2.1 SCIENCE PLATFORM: *CCGS Louis S. St-Laurent*

The *CCGS Louis S. St-Laurent* is a 26,000 HP Canadian Coast Guard icebreaker equipped with helicopter and deployable rigid hull boats. An ice specialist from the Canadian Ice Service received frequent Radarsat ice images and weather forecast information from shore, sent daily ice and weather observations back to shore, and assisted in navigation and information regarding science station locations.

The Canada Basin was ice covered from roughly 72°N to the north during August, 2005 and thus operations were dependent on the ship making openings in the ice to allow deployments and recoveries. Mooring and vertical net tow operations were performed from the ship's foredeck using the starboard crane and A-frame. CTD/Rosette casts were performed using an A-frame, mid-ships, on the boat deck's starboard side. XCTDs were deployed from the aft deck by a handheld launcher. Ice buoys were deployed away from the ship, using a portable gantry set up on the ice.

The ship's forward science lab was used as a mooring instrument shop, the rosette and CTD operations were performed from the boat deck container labs. Nutrient, oxygen, CFC, alkalinity and chlorophyll analyses were performed in the main lab. Salinity analysis was performed in the more temperature stable after-lab. Zooplankton operations were split between the well-ventilated container lab on the foredeck and the after-lab.

Ships soundings were taken using a 12-kHz Knudsen portable sounder using an over-the-side transducer as the ship's ELAC 15 kHz depth sounder failed during the cruise. Continuous measurements were not possible.

2.2 FIELD SAMPLING: CTD/ROSETTE CASTS

Rosette casts were taken with a Seabird SBE911plus CTD system, operating at a 24Hz scan rate, equipped with dual temperature sensors, dual conductivity sensors, SBE43 oxygen probe, Wetlabs CST–DR transmissometer, Seapoint pumped fluorometer, bottom contact warning device and a Datasonics altimeter. See **Appendix 3** for sensor serial numbers, calibration information and position on frame. In addition, an RDI downward-looking lowered acoustic doppler profiler (LADCP) was mounted near the bottom of the frame, inside the ring of Niskin bottles. Twenty-four 10 Liter Niskin bottles with internal stainless steel springs made by OceanTest Equipment, were used to collect water samples at all stations for salinity, dissolved oxygen, nutrients, $\delta^{18}O$, barium, alkalinity (FW), chlorophyll-a and phaeopigment, bacteria and ^{13}C

measurements; at most stations for CFC-11, CFC-12, CFC-113, CCl_4; and at select stations for ^{137}Cs, ^{129}I, DIC, TOC, CDOM and ammonium samples.

A typical full depth cast (>3000 m) took 3.5 hours to complete. The ship stopped near the pre-determined location to find a position that would keep the wire clear of ice during the deployment. If ice approached the wire during deployment the wire was moved closer to the ship for protection or the winch spooling stopped while the ice pushed by, preventing the wire from sawing into and getting caught in the ice. The ship's bubbler system was also used to push ice out of the way although the bubblers' location is most suited to clear the foredeck area, forward of the CTD/rosette launch area.

The CTD/rosette package was rolled out of the heated sampling container, the protective water-filled plugs removed from the temperature, conductivity and oxygen sensors, and the CTD turned on while still on deck to record in-air information. The CTD/rosette was deployed after communication was established between the CTD, SBE 32 water sampler and computer, connected by 5500 m of single conductor CTD wire.

Using a newly re-conditioned winch, now part of the ship's equipment, the rosette was lowered to 10 m, the sensor pumps turned on and the package soaked for 3 minutes to equilibrate the oxygen sensor. The package was then raised to just below the surface, then lowered at 30 m/min to 300 m, increasing to 60 m/min to within 10 m of the ocean floor. After closing the first bottle at the bottom of the cast, the package was raised at 60 m/min then slowed to 30 m/min for the upper 300 m. There was typically a stop at 900 m in both directions to change the winch gearing between high and low. Bottles were closed on the upcast without slowing the raising speed to capture the least disturbed water. In the upper 400 m, the sample depths were chosen to match selected salinity values. During the downcast, the depths of the salinity values were noted and on the upcast, bottles were closed at these pre-determined depths.

CTD data acquisition was not stopped until after the CTD/rosette was brought back on deck, again to record in-air measurements. The CTD/rosette was rolled back into the heated rosette room, the water-filled sensor plugs reattached and the water sampler and LADCP rinsed with fresh water. Care was taken to avoid rinsing the Niskin bottles prior to being sampled.

Water sampling took place immediately after each cast, the gas samples being collected first. Halocarbons, dissolved oxygen, nutrients, salinity, alkalinity, ammonium, chlorophyll-a and phaeopigments were measured on board. All other samples were stored for analysis onshore.

2.2.1 Reported Data

2.2.1.1 Downcast CTD Files

The downcast CTD data are provided in 1-db averaged files with one file per cast. Standard Seabird processing steps were used. Pressure, primary temperature, secondary conductivity and oxygen were calibrated. Data from spikes in temperature, salinity and oxygen were replaced with linearly interpolated data. Transmission, fluorescence and altimetry data were not calibrated.

2.2.1.2 Chemistry

All water sample data are provided in a spreadsheet that includes station name, location, time, associated CTD data, and are referenced to a unique sample number.

2.3 CTD DATA ACQUISITION, PROCESSING AND VALIDATION

2.3.1 Overview/Highlights

The raw CTD data contained more spikes than in past cruises, likely due to an electrical connection problem. These spikes were removed either through filtering or linearly interpolating over the bad data. CTD cast notes, cast numbers and depth where interpolation of data were required are listed in **Appendix 4**.

The SBE43 oxygen sensor's membrane progressively detached from the housing due to assembly errors at Seabird which caused the sensor's calibration to shift, sometimes with each cast. In addition to the drift, the oxygen voltage frequently dropped to zero, although only for short periods, requiring linear interpolation over the bad data.

The transmissometer data had intermittent jumps associated with depth. The sensor had been mounted vertically in the rosette frame. When the sensor was repositioned horizontally after cast 23, the data improved.

The pylons (SBE 32 Carousel Water Sampler) had problems with sticking latches thought to be due to grease from the sea cable coming in contact with the pylon during the recoveries when the CTD/rosette was brought back on deck. The pylon heads (primary and backup) that hold the individual latches were exchanged as needed. The removed head was soaked and scrubbed using soapy water and rinsed thoroughly. In addition, communication errors with the pylon meant some Niskins required two attempts to close which resulted in slightly offset target depths. See Table 1 for details on CTD accuracy.

Table 1. CTD Accuracy for 2005-04.

Sensor	Accuracy (Standard Deviation)	Lab Calibration Applied	Correction to Lab Calibration	Comment
Pressure	1 db	29-Oct-02	None	
Temperature, Primary	0.001 °C	Pre cruise (05Oct2004)	None	
Temperature, Secondary	0.001 °C	Pre cruise (05Oct2004)	None	Not checked for data spikes.
Conductivity, Primary	0.0006 mS/cm deeper than 2000 m	Pre cruise (05Oct2004)	-0.0018 mS/cm.	From water sample comparisons
Conductivity, Secondary	0.0006 mS/cm deeper than 2000 m	Pre cruise (05Oct2004)	-0.0002 mS/cm	From water sample comparisons. Not checked for data spikes.
Salinity, Primary	0.0015 below 500 m	NA	NA	Recalculated with calibrated conductivity
Salinity, Secondary	0.0015 below 500 m	NA	NA	Recalculated with calibrated conductivity. Not checked for data spikes.
Oxygen	0.06 mL/L	Pre cruise (14Mar2005)	Updated terms: lag, voffset, soc	From water sample comparisons
Transmission	NA	None	None	No calibration
Fluorescence	NA, minimum detection level is 0.02 mg/m^3	None	None	No calibration
Altimeter	NA	None	None	No calibration

2.3.2 Acquisition and Processing Steps

CTD data were acquired and processed with Seabird software on a PC platform. Acquisition occurred real-time through a conducting cable from the CTD to a PC running Seasave (Seasave Win32 V 5.28c). The ship's GPS position was added to each data scan via the NMEA interface. Upon completion of the station, the data were copied to a new directory and Seabird's Windows-based processing software, SBEDataProcessing, was used to produce

1 db averaged downcast and upcast profiles. The standard processing steps were: sensor alignment through advancing conductivity; spike removal; a correction for the thermal mass of the temperature sensors; filtering; removal of pressure reversals; calculation of oxygen; averaging to 1 db levels; calculation of other derived properties; and file separation between downcast and upcast profiles.

Final processing was completed using Matlab routines to calibrate, plot and remove spikes in the data. The primary conductivity sensor was calibrated to the salinity of deep water samples. The calibrated conductivity was then used to determine a standard bottle depth offset due to closing bottles 'on-the-fly' through comparisons with salinities from shallow water samples. Using the bottle depths as determined above, the downcast oxygen sensor data were then calibrated with the bottle oxygen data. Data were plotted station by station to identify density inversions in the downcast. Inversions were replaced with interpolated primary temperature and conductivity sensor data, and the derived properties (salinity, density, theta) recalculated. The interpolations are listed in **Appendix 4**. The fluorometer, transmissometer and altimeter data are unprocessed.

2.3.3 CTD Pressure

The instrument did not receive a pre- or post-cruise calibration. There is insignificant surface bias from the on-deck readings, and salinity comparisons provide no reason to suspect the deep pressure readings. The average surface biases at the start and end of the casts were +0.0 db and -0.1 db, respectively. The standard deviation was low, 0.1 db for each. The end-of-cast bias is so small it has been ignored. The Seabird reported SBE9plus pressure accuracy is 0.015% of full scale, 1 m at 6800 m.

2.3.4 CTD Temperature

Pre- and post-cruise laboratory calibrations performed by Seabird Inc. show negligible sensor drift. Over the 16 month period between pre and post cruise calibrations, both primary and secondary sensors changed by less than +0.0005 °C over the range of interest (-2 to 10 °C) as shown in Figure 7. Comparisons between the primary and secondary sensors in the station data show very little difference throughout the cruise (0.00016 °C below 1000 db with standard deviation of 0.00011 °C between casts). No adjustments other than interpolation at data spikes (described and listed below) were performed. The reported data were calibrated with the pre-cruise laboratory calibration.

Stated SBE9plus Temperature Accuracy is 0.001 °C. Results suggest this is appropriate for this data set.

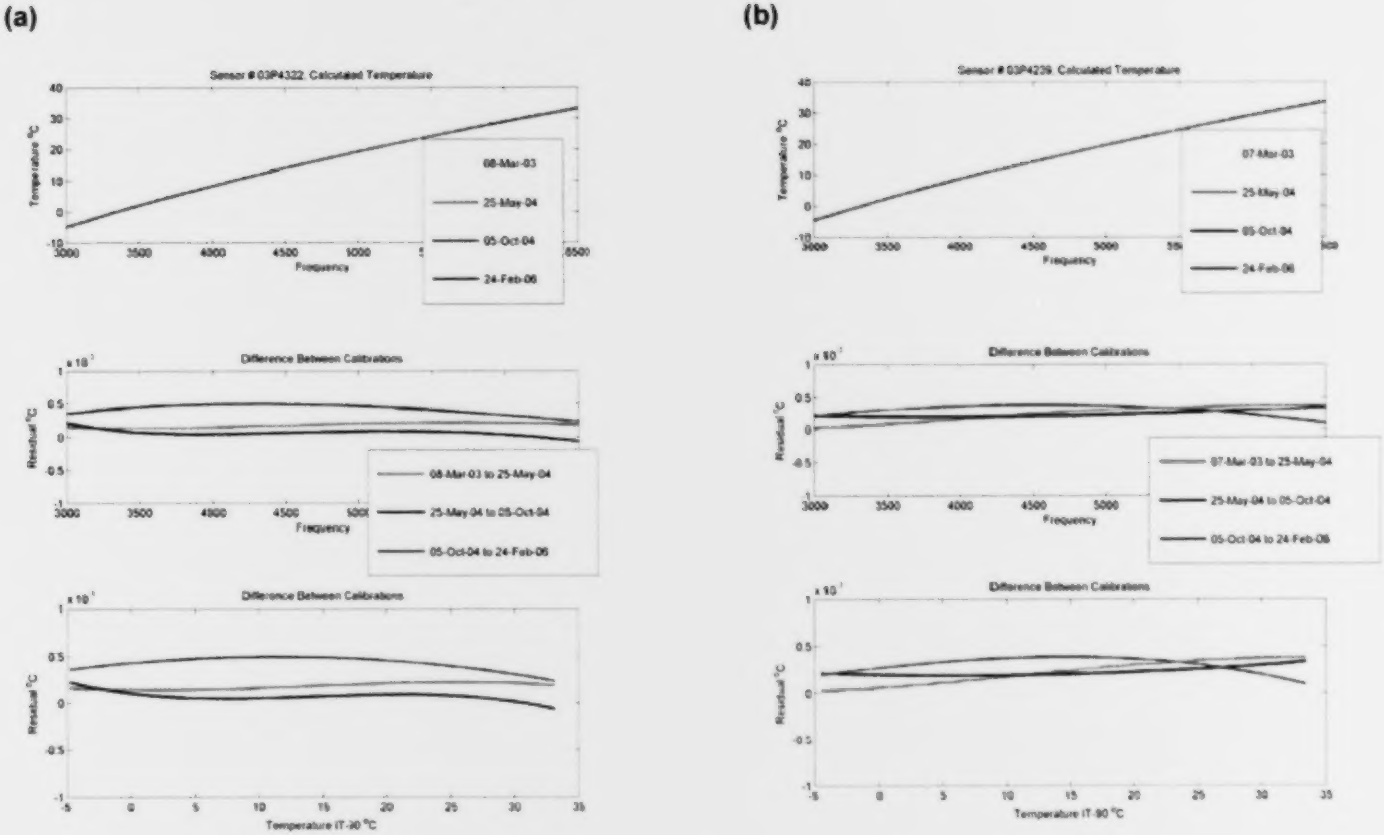

Figure 7. Lab calibration of (a) primary temperature sensor #4322; and (b) secondary temperature sensor #4239. The red line shows the calibration change for this cruise (from 5 Oct 2004 to 24 Feb 2006).

2.3.5 CTD Conductivity

The conductivity sensors were stable throughout the cruise. Lab calibrations, dual sensor comparisons and water sample comparisons were examined. For the primary conductivity sensor, lab calibrations agreed with water sample calibration, which required a change of -0.0018 mS/cm. The secondary conductivity sensor required a change of -0.0002 mS/cm. Dual sensor comparisons and deep water comparisons do not suggest a calibration drift during the cruise.

Laboratory Results

Pre and post cruise laboratory calibrations show there was a noticeable change in the sensors. Over the range of conductivities measured on the cruise, 21 to 31 mS/cm, the primary conductivity changed between -0.0010 and -0.0015 mS/cm; secondary conductivity shows a shift over the same range from +0.0005 to -0.0003 mS/cm (Figure 8).

Dual Sensor Results

Comparisons between primary and secondary sensors show a constant offset during the cruise in the deep water. Using pre-cruise calibrations, the average offset was 0.0013 mS/cm (0.0018 PSU) below 1000 db with a standard deviation (STD) of 0.0001 mS/cm (0.0001 PSU). Averages of each cast were used to find the cruise average and STD.

Bottle Salt Results

Bottle salts were used to calibrate the primary and secondary conductivity sensors. The majority of samples were taken on the fly during the upcast. To remove bottle flushing effects, only the deep water below 2000 db where the vertical gradient is small (less than 0.005PSU over 200 m), was used for calibration. An iterative fitting routine was used with a standard deviation criterion of 2.5 (Figure 9).

- Primary conductivity bias: +0.0018 mS/cm; STD 0.0006 mS/cm; 50 out of 59 observations used in the calculation
- Secondary conductivity bias: +0.0002 mS/cm; STD 0.0006 mS/cm; 50 out of 59 observations used in the calculation.

There was a residual difference between the calibrated CTD and the water samples of 0.001 mS/cm (CTD fresher than water samples) at 700 m depth in both sensors. The data were not corrected for this difference.

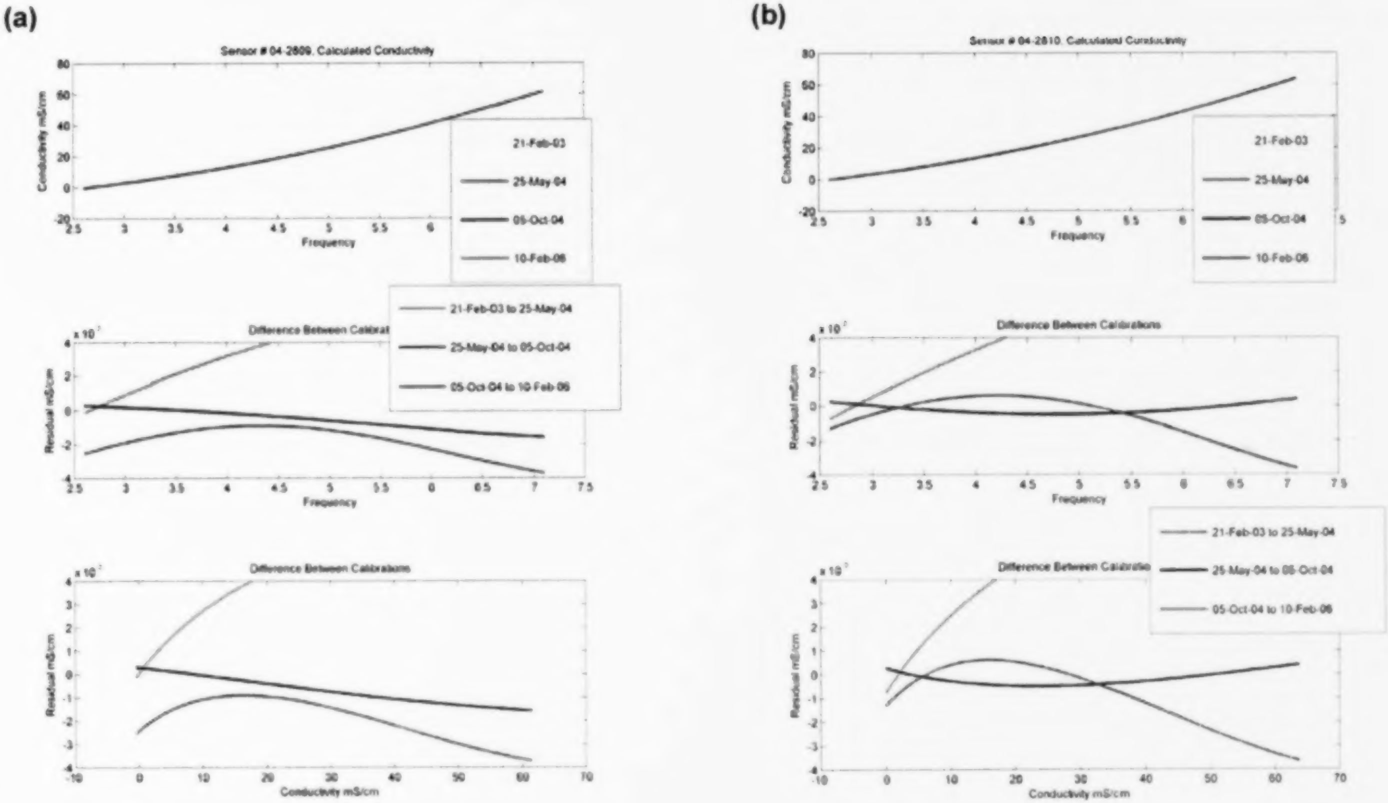

Figure 8. Lab calibration of (a) primary conductivity #2809; and (b) secondary conductivity #2810. The red line shows the calibration change for this cruise (from 5 Oct 2004 to 10 Feb 2006)

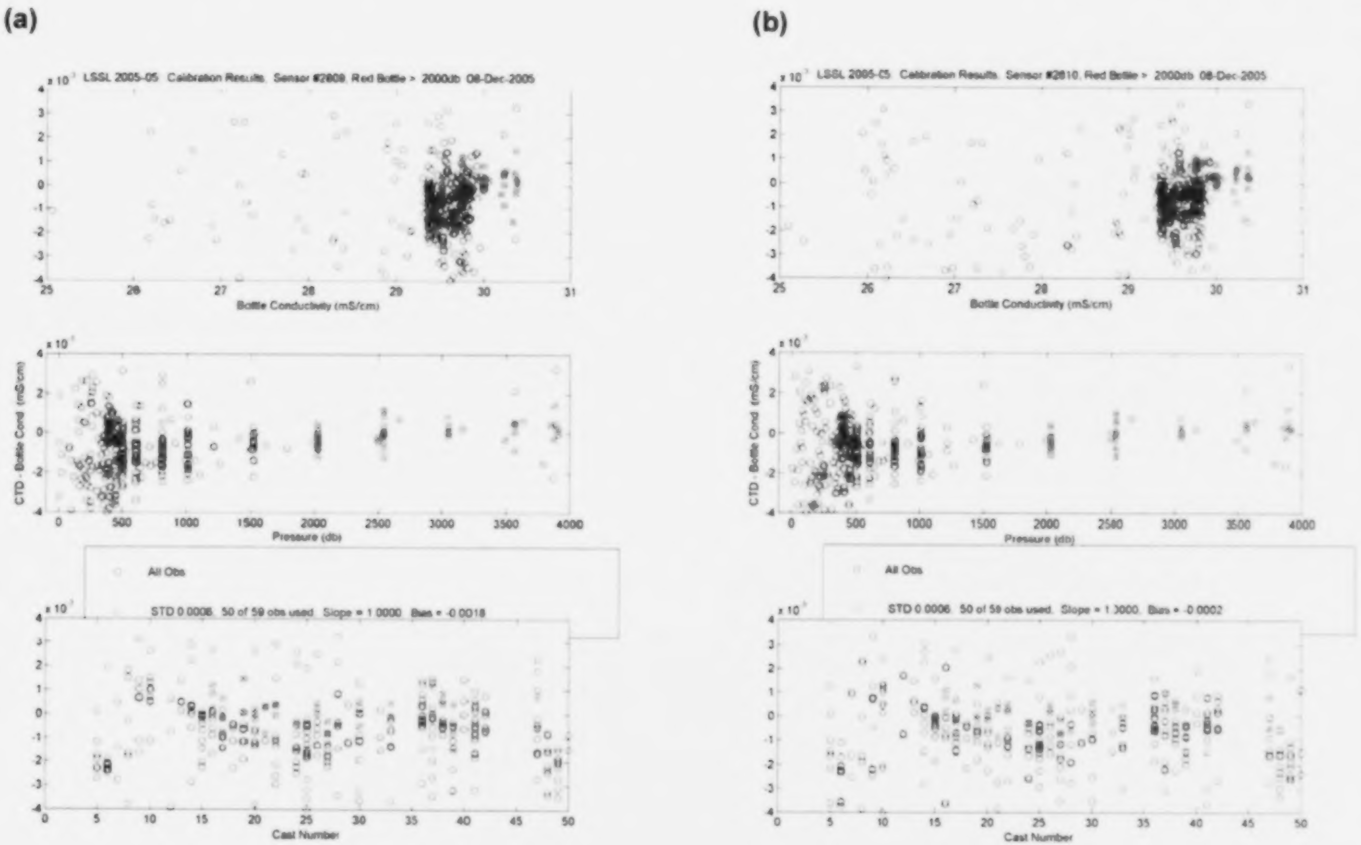

Figure 9. Calibration of (a) primary conductivity #2809 and (b) secondary conductivity #2810 to water samples. The samples in red were those used in the calibration.

2.3.6 CTD Salinity

CTD salinity was recalculated from the calibrated conductivity (Table 2). The bottles to CTD comparisons do not agree as well in shallow water (0 to 300 m) (Figure 10 and Figure 11) where there are large vertical gradients. The best measure of CTD salinity accuracy is provided by the deep water comparisons (Section 2.3.11) and can be considered ± 0.0015.

Table 2. Comparison of calibrated CTD salinity and water sample data using CTD - Water Sample.

Depth Range (db)	STD	Mean	Number of Observations
500 to 4000	0.0015	0.0000	230
300 to 500	0.0032	0.0002	112
0 to 300	0.2085	0.0029	432

The final CTD salinity of the deep Canada Basin in 2005 was very close to the measurements made in other years. The deep salinity value was 34.9568 compared to the mean 34.9571 (using water samples from 9 cruises over the years 2002 to 2007).

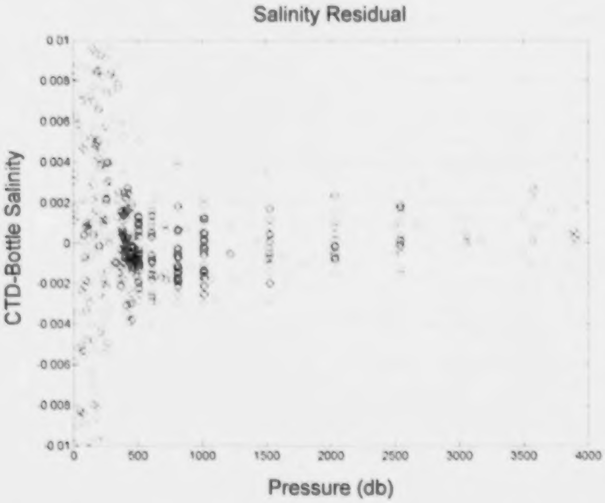

Figure 10. Salinity residual (CTD - Salinity) scaled to show deep water residuals.

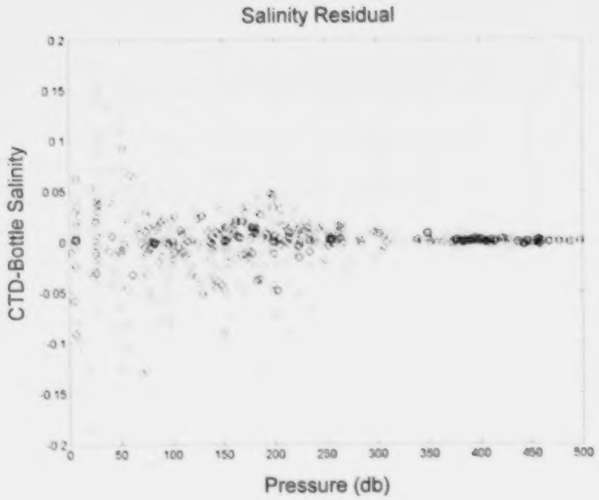

Figure 11. Salinity residual (CTD - Salinity) shown for the top 500 db.

2.3.7 CTD Oxygen

Performance

There was a manufacturing defect with the SBE43 oxygen sensor resulting in a large calibration drift during the cruise. Seabird reported they had a problem with the membrane adhesion to the sensor during manufacture. This resulted in poor quality CTD oxygen.

Comparison of calibrated CTD oxygen and water sample data produces a STD of 0.06mL/L based on residuals of 634 observations (after outliers removed). Segmented into depth ranges this STDs are: 0.08mL/L from 0 to 300db, 0.03mL/L from 300 to 500db and 0.02mL/L from 500 to 4000db (see Table 3).

Problems addressed:

- Numerous spikes to zero oxygen voltage, primarily in water over 200 m deep. The standard filtering routine did not catch all the spikes so criteria were put into place to linearly interpolate over the low voltage values.
- A strong calibration drift towards lower oxygen voltages occurred over first 20 stations, then stabilized. Calibration to water samples required 19 station groupings.
- After applying the standard calibration method, there still remained a pressure dependent shape which was removed by subtracting the mean shape.

Calibration

The downcast oxygen data were calibrated to the upcast oxygen water samples, with consideration given to the sensor lag, hysteresis, and water sample quality. Coefficients were found following the Seabird method (Application Note 64-2: http://www.seabird.com/application_notes/AN64-2.htm). New sets of coefficients were determined for two of the six coefficients (voffset and soc) and were applied with the remaining pre-cruise laboratory calibration coefficients and lag value.

The lag of the oxygen voltage was determined by comparing similar oxygen voltage features in the down and upcasts. A lag between 6 and 12 seconds was found, depending on depth and cast. Seabird now has a new algorithm that applies a variable lag, dependant on depth and temperature but at the time of this processing, a fixed lag of 6 seconds was chosen and profiles were best matched vertically for the upper 500 m. Oxygen voltage was moved 6 seconds ahead of the other sensors to correct for the sensor lag.

Hysteresis in the oxygen voltage meant at a given depth, upcast oxygen voltage was consistently lower than the downcast voltage. The deeper and longer the sensor was at depth, the larger the hysteresis. Hystereis occurred in casts that went deeper than 1000 db with upcast showing the effect even into the shallow water (~400 m). This variable hysteresis in the upcast was too difficult to correct, so only the downcasts were calibrated. The downcast CTD data were taken at bottle trip pressures (after the bottle flushing correction) and compared to water samples. There will be some error due to the real difference between down and upcast profiles.

Table 3. Coefficients for CTD oxygen equation using lag-corrected oxygen voltage.

Casts	Boc	Tau	Tcor	Pcor	Voffset	Soc
1 to 5	0	0	-0.0006	0.000135	-0.544455795	0.550740507
6	0	0	-0.0006	0.000135	-0.60185	0.57887
7, 8	0	0	-0.0006	0.000135	-0.595616932	0.585992173
9, 10	0	0	-0.0006	0.000135	-0.504155355	0.552128103
11, 12	0	0	-0.0006	0.000135	-0.576694713	0.592991424
13, 14	0	0	-0.0006	0.000135	-0.485805159	0.554237363
15	0	0	-0.0006	0.000135	-0.334878142	0.500744308
16	0	0	-0.0006	0.000135	-0.416599467	0.549951469
17	0	0	-0.0006	0.000135	-0.405902694	0.555633387
18,19	0	0	-0.0006	0.000135	-0.4420742	0.591705719
20	0	0	-0.0006	0.000135	-0.441308727	0.59948915
21	0	0	-0.0006	0.000135	-0.438927933	0.606237172
22, 23	0	0	-0.0006	0.000135	-0.44887146	0.616929635
24	0	0	-0.0006	0.000135	-0.431060849	0.603111074
25	0	0	-0.0006	0.000135	-0.419116394	0.596477465
26 to 31	0	0	-0.0006	0.000135	-0.442988848	0.608050828
32 to 34	0	0	-0.0006	0.000135	-0.419598179	0.596906257
35 to 38	0	0	-0.0006	0.000135	-0.452943985	0.611074682
39 to 50	0	0	-0.0006	0.000135	-0.434263041	0.593142587

After applying the standard calibration method, there still remained a pressure dependent shape in the residual between water sample and CTD oxygen. This was removed by subtracting the mean shape shown by the black line in Figure 12.

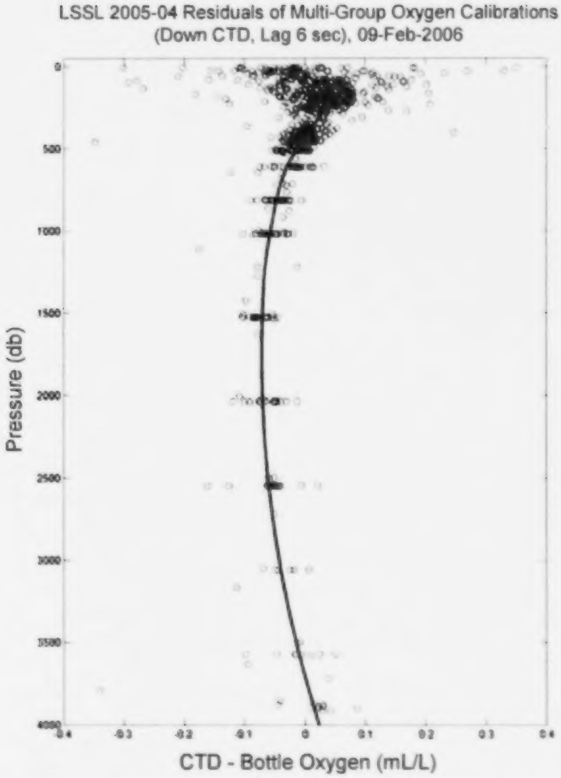

Figure 12. A pressure dependant shape in the oxygen residual was removed by subtracting the mean shown by the black line.

Comparison of calibrated CTD oxygen and water sample data produced a STD of 0.06 mL/L based on the residuals of 634 observations (after outliers removed: Table 4; Figure 13).

Table 4. Comparison of calibrated CTD oxygen and water sample data.

Depth Range (db)	STD	Mean	Number of Observations
500 to 4000	0.021	0.005	179
300 to 500	0.025	0.001	107
0 to 300	0.082	0.016	348
Full Depth, 0 to 4000	0.063	0.010	634

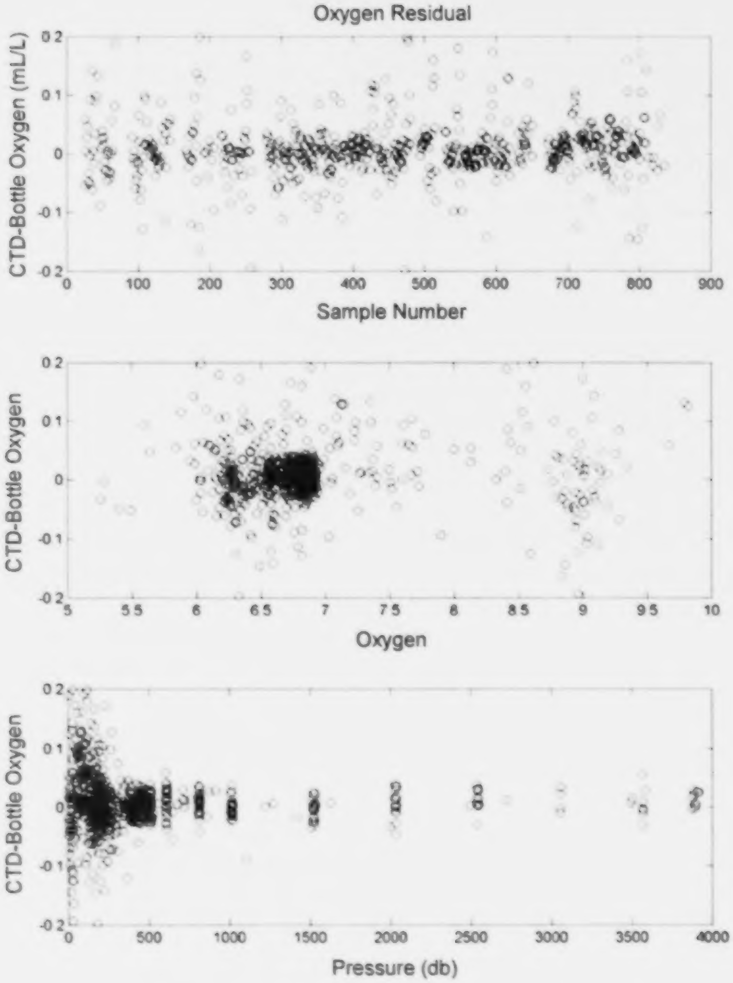

Figure 13. Oxygen residuals (CTD - Bottle).

2.3.8 CTD Transmission

The WETLabs CSTAR transmissometer (DR pathlength 25cm) data were not processed except to apply the factory calibration from 20 March 2003 to compute percent transmission. The windows were wiped prior to each cast as part of the CTD launching routine. A problem was experienced during the cruise where the transmission value would shift lower then back to normal values. This often occurred over the same depth range and repeated on the upcast. After cast 23, the transmissometer was remounted on the rosette frame from a vertical to a horizontal position and the shifting was reduced. One explanation is that pressure affected the sensor body resulting in misalignment between the beam's transmitter and receiver thereby reducing the transmission value.

Serial number: CST-662DR
Calibrated on: 20-Mar-2003
M: 18.9000
B: -1.0200
Path length: 0.250 m

M and B as defined in Seabird Application Note 7 (Seabird 2008).

Units were converted from [%] with pathlength 0.25 m to a standardized [%/m] where pathlength is 1 m.

2.3.9 CTD Fluorescence

The CTD fluorometer measures both chlorophyll and phaeopigments, however the instrument is typically calibrated to chlorophyll alone as this is the desired measurement from the sensor. However, the Seapoint fluorometer data were not calibrated. Chlorophyll-a data were collected and comparisons could be performed to calibrate the fluorescence data (Figure 14). A 30x gain cable was used with the fluorometer such that the 0-5V fluorometer output is linearly converted to 0 to 5 mg/m^3. The Seapoint fluorometer minimum detection level is 0.02 mg/m^3. Water was pumped past the fluorometer, following the temperature and conductivity sensors, improving the consistency of the reading. The covered housing on the fluorometer prevented cleaning during the cruise.

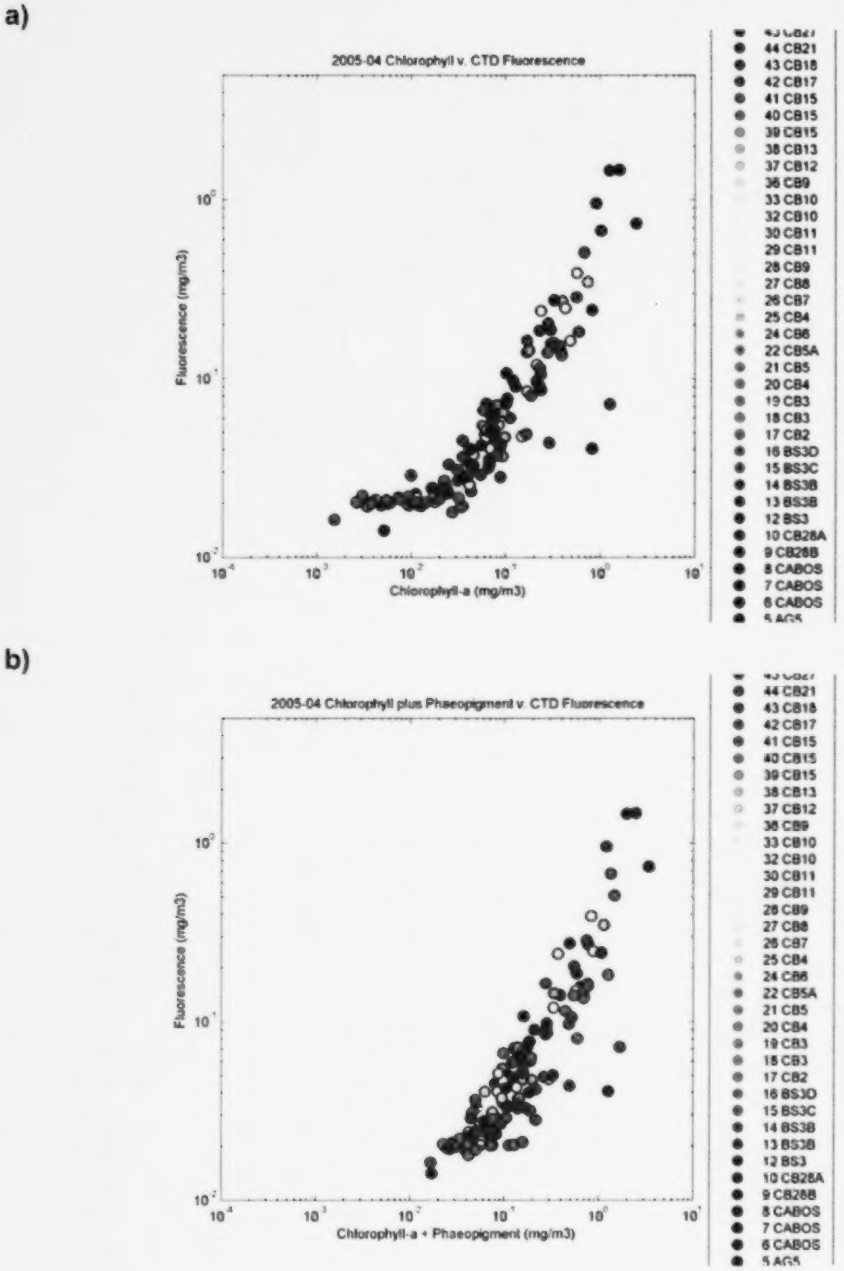

Figure 14. Plot of uncalibrated CTD fluorometer data against a) sample chlorophyll and b) chlorophyll plus phaeopigments.

2.3.10 Data Spike Removal

Data spikes were found in primary temperature and primary conductivity using the density inversion criteria listed below. Linear interpolations were performed on both primary temperature and primary conductivity if a spike was found in either property. Calculated variables including salinity were re-calculated following the interpolations. Interpolations were also performed for spikes found in oxygen data, however due to the numerous short interpolations required when the oxygen voltage dropped to 0, only the large oxygen interpolations are listed. Interpolation intervals were all less than 10 m except in casts 34, 43, 44, and 48.

Criteria for temperature and salinity spike identification:
0 to 10 m, density inversions typically ignored
10 to 200 m, density inversions over 0.004 kg/m³/m
200 to 600 m, density inversions over 0.001 kg/m³/m
600 m and deeper, density inversions over 0.0005 kg/m³/m

Casts 25 and 28 had sections with bad primary salinity. Both primary temperature and conductivity were replaced by the secondary sensor values.

Cast number and depth where interpolation of CTD data was required are listed in **Appendix 4**.

2.3.11 CTD Data at Bottle Depths for Water Chemistry File

Because the Niskin bottles were closed on-the-fly, salinity comparisons between water samples and CTD in the upper 300 m were used to determine which CTD data to match with the water samples. Due to bottle flushing lags, the water in the bottles comes from slightly deeper than the depth of the CTD measurement. By applying a standard offset to the CTD data, these data were matched to the water collected in the Niskin.

The appropriate lag was found by comparing 0.2 second averaged CTD data (after applying conductivity calibration) to the bottle data. The comparisons were restricted to the upper 300 m where the vertical salinity gradient is large. Between 100 and 200 db, the vertical salinity gradient is 0.01 to 0.02 /db and with wire-speeds from 0.4 m/s to 1.0 m/s temporal salinity gradients of 0.008 to 0.012 /s are created. CTD salinity from -10 to 0 seconds prior to bottle closure were compared with the bottle salinities. Casts where the CTD rosette was stopped (7,8,13,18,29,32 and 40) were excluded.

The bottle salinity and CTD salinity had the smallest mean difference at -2.6 seconds (meaning the CTD data are from -2.6 seconds before bottle closure), using STD of 2.5. There is a positive skew to the data, however, where bottle salinity is higher than CTD salinity, indicating bottles are not uniformly flushed and outliers are biased to not flushing. It should be noted that the alternative, stopping the package for a bottle sample, also results in a bias due to the lack of normal ship-rock in ice covered waters that would mechanically flush the bottles. Closing on-the-fly is considered to reduce the size of the bias, and produce a more repeatable response than stopping the package for bottle closures.

Refer to Figure 15 for comparisons within 2.5 STD, 0 to 300 db, using calibrated CTD salinity:

(a) No Correction
    Mean = 0.0095 PSU, STD =0.0097 PSU, 182 obs
(b) -2.6 Seconds
    Mean = -0.0004 PSU, STD = 0.0214 PSU, 337 obs

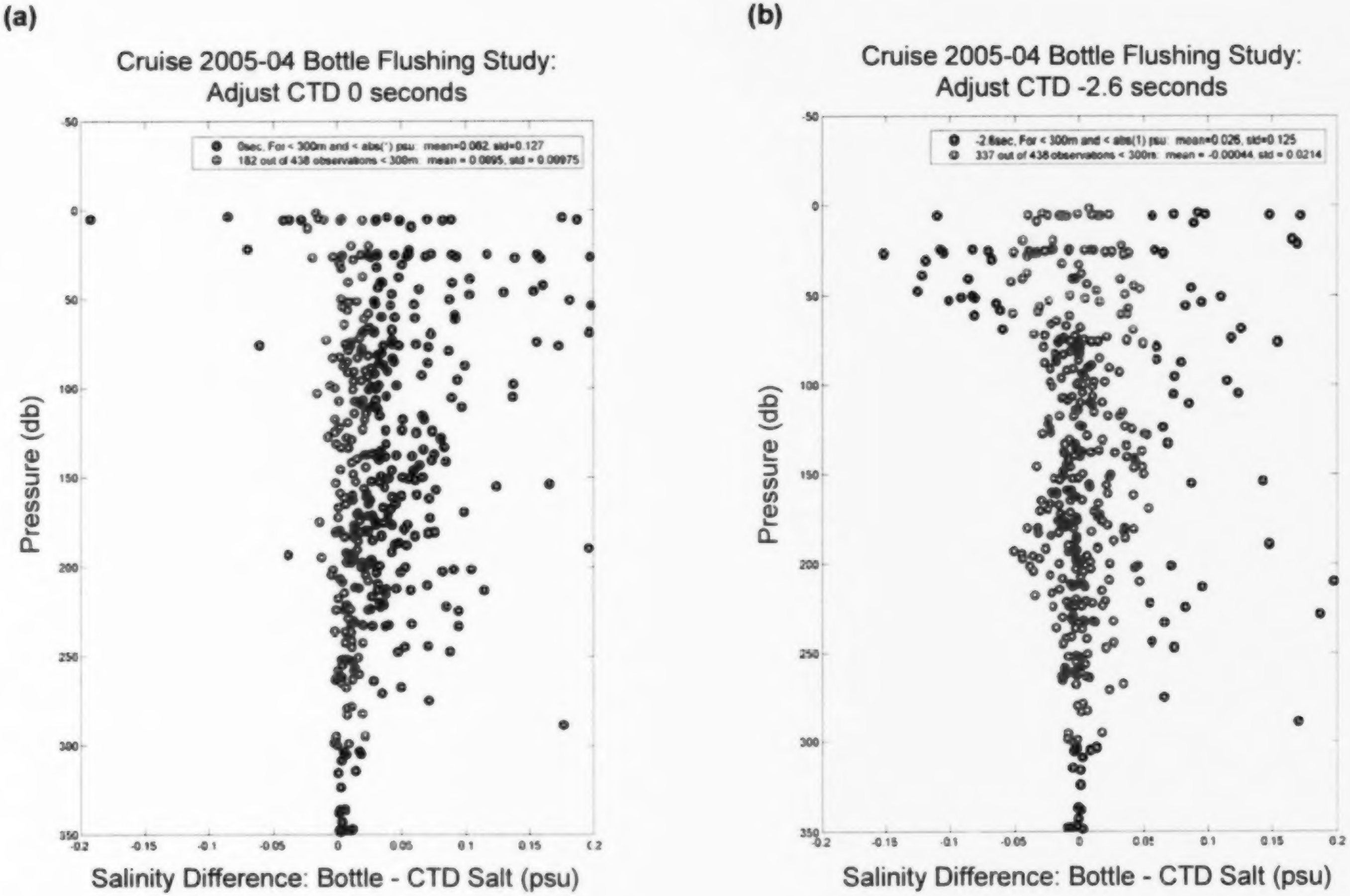

Figure 15. Applying (a) no lag correction; and (b) a -2.6 s lag correction.

2.4 CHEMISTRY SAMPLING AND ANALYSIS

2.4.1 Overview/Highlights

Samples were collected for water properties listed below in Table 5.

Note: Contamination compromised ammonium analysis and data are not reported; CDOM samples were compromised during storage and therefore not analyzed; ^{13}C samples have not been analyzed to date (January 2010).

Table 5. Water Sample Summary

Parameter	**Canada Basin Casts (Casts 6 to 50)**	**Depths**	**Analyzed**	**Investigator**	**Comment**
Salinity	All	all	Ship and lab	Fiona McLaughlin (IOS)	In report
Dissolved Oxygen	All	all	Ship	Fiona McLaughlin (IOS)	In report
Nutrients (Nitrate, Silicate, Phosphate)	All	all	Ship	Fiona McLaughlin (IOS)	In report
Halocarbons (CFC11,CFC12, CFC113 & CCl_4)	Most	Full range	Ship	Fiona McLaughlin (IOS)	In report
Oxygen-18 isotope (^{18}O)	All	0 to 500m and 1 deep	Lab	Fiona McLaughlin (IOS)	In report
Barium (Ba)	All	0 to 500m and 1 deep	Lab	Chris Guay (OSU)	In report
Dissolved Inorganic Carbon (DIC) & Alkalinity	20,28,39,43	Full Depth	Lab	Fiona McLaughlin (IOS)	In report
Alkalinity (Fresh Water)	All	0 to 500m	Ship	Michiyo Kawai (IOS)	In report
Total Organic Carbon (TOC)	20,28,39,43	Full Depth	Lab	Fiona McLaughlin (IOS)	In report
Chlorophyll-a & Phaeopigment (Total using 0.7µm filter)	All	0 to 150m	Ship	Fiona McLaughlin (IOS)	In report
Bacteria	All	0 to 250m, 1deep	Lab	Bill Li (BIO)	In report
Iodine-129 isotope (^{129}I)	13,18-20,25,29, 30,32,33,39-41, 44,45	100 to1000m or Full depth	Lab	John Smith (BIO)	In report
Cesium-137 isotope (^{137}Cs)	13,18, 29, 32, 40	100 to1000m	Lab	John Smith (BIO)	In report
Carbon-13 isotope (^{13}C)	All	Surface	Lab	CS Wong (IOS)	Not analyzed to date (Jan 2010)

The precision of the methods was estimated by analyzing replicates and is expressed as the pooled standard deviation, s_p, and calculated using the equation:

$$s_p = \sqrt{\frac{\sum [c(1) - c(2)]^2}{2n}}$$

where $c(1)$ and $c(2)$ are the concentrations of duplicate samples and n refers to the number of pairs. The precision of the reported data are summarized below in Table 6. Outliers are removed according to Chauvenet's Criterion (Taylor 1997).

All samples were referenced to a unique sample number associated to each Niskin closure.

See **Appendix 5** for single cast plots, **Appendix 6** for group property-property plots and **Appendix 7** for section plots.

Note:

Communication errors with the pylon while bottle tripping meant some bottles required two attempts to close the bottle resulting in slightly offset target depths.

Table 6. Water Sample Precision

Chemistry Sample	Precision (s_p)	Number of Replicates (n)	Minimum Range	Maximum Range
Salinity (at sea 500 to 4000 db)	0.0010 PSU	35	34.78 PSU	34.96 PSU
Dissolved Oxygen	0.022 mL/L	87	5.28 mL/L	9.78 mL/L
Nitrate	0.08 mmol/m^3	93	0.0 mmol/m^3	16.5 mmol/m^3
Silicate	0.10 mmol/m^3	92	1.4 mmol/m^3	39.0 mmol/m^3
Phosphate	0.01 mmol/m^3	94	0.36 mmol/m^3	2.05 mmol/m^3
CFC-12	0.03 nmol/m^3	39	0.00 nmol/m^3	4.97 nmol/m^3
CFC-11	0.09 nmol/m^3	39	0.00 nmol/m^3	8.21 nmol/m^3
CFC-113	0.03 nmol/m^3	39	0.00 nmol/m^3	0.80 nmol/m^3
CCl_4	0.31 nmol/m^3	39	0.00 nmol/m^3	12.1 nmol/m^3
$\delta^{18}O$	0.07‰	39	-5.27‰	0.85‰
Barium	2.56 µmol/m^3	44	42.19 µmol/m^3	120.47 µmol/m^3
DIC	1.52 µmol/kg	6	1860.6 µmol/kg	2240.3 µmol/kg
Alkalinity (from DIC sample)	2.43 µmol/kg	7	1972.1 µmol/kg	2791.1 µmol/kg
Alkalinity	9.7 µmol/kg	118	1865.9 µmol/kg	2324.5 µmol/kg
TOC	1.9 µM	—	34.6 mmol/m^3	71.6 mmol/m^3
Total Chlorophyll-a	0.006 mg/m^3	22	0.0 mg/m^3	2.4 mg/m^3
Total Phaeopigment	0.020 mg/m^3	22	0.01 mg/m^3	0.98 mg/m^3

2.4.1.1 Salinity

Samples were primarily run at sea however the last four casts and surface samples taken by bucket were brought back for analysis at IOS due to time constraints at the end of the cruise.

Analysis at Sea

Onboard, samples were analyzed on the Guildline Autosalinometer Model 8400A (SN: 49463) by Hugh Maclean. Procedure followed methods as outlined in the standard IOS protocol. Water samples were collected from Niskin bottles immediately following a rosette cast. Salinity bottles were used with a two cap system, an insert cap followed by a screw on cap. Salinity bottles and insert caps were rinsed 3 times before filling. Samples were transferred to the temperature controlled room for storage until they were analyzed within one week of collection. Room and sample temperature was maintained consistently between 21 and 23 °C. Bottles were inverted and mixed prior to analysis.

IAPSO Standard Seawater (OSIL, batch P144, 23Sep2003) was measured at the beginning and end of each run to calibrate the Autosal and identify instrumental drift. The value of OSIL, batch P144 is 34.995 PSU. Data are reported in practical salinity units (PSU) (Lewis & Perkin 1978).

A slight drift in the autosalinometer during the at-sea analysis required a correction to the measurements. The drift was between -0.0014 and +0.002 PSU per run. A linear correction for the drift was applied based on run number, thus the first sample run received no correction and the last sample received the full drift correction.

Analysis Onshore

Onshore, samples were analyzed on the Guildline Portasalinometer by Bernard Minkley. Procedure followed methods as outlined in the standard IOS protocol. IAPSO Standard Seawater (OSIL, batch P144) was run before and after the analysis. The standard seawater shows a conductivity difference with the portasalinometer of $-4e^{-6}$ prior to the analysis and $-3e^{-6}$ after the analysis. A value of $-4e^{-6}$ was applied for the conductivity correction followed by the computation of salinity.

See Table 7 for details on Autosal and Portosal drift during analysis runs and Table 8 for precision of salinity samples.

Table 7. Drift in Autosal and Portosal during analysis runs.

Run Number	Sample Numbers	Number of Samples in Run	Drift (PSU)
Samples Run On Board			
1	0.5 to 8	18	Na
2	9 to 87	91	-0.0010
3	88 to 183	94	0.0020
4	184 to 314	127	0.0012
5	315 to 409	107	-0.0010
6	410 to 552	142	-0.0014
7	553 to 617	68	-0.0002
8	618 to 710	90	0.0000
9	711 to 811	116	-0.0012
Samples Run Onshore at IOS			
101	812 to 895, 3002 to 3039	57	0.000001 conductivity ratio

Table 8. Precision of salinity samples analyzed at sea and onshore.

Samples	s_p	n	No. outliers removed
At sea and onshore combined	0.0046 PSU	94	3
At sea all depths	0.0049 PSU	81	2
At sea 500 to 4000 db	0.0010 PSU	35	1
Onshore all depths	0.0016 PSU	13	1

For salts from depths greater than 2950 m (homogenous bottom water): Standard deviation is 0.001 PSU for 28 observations with an average of 34.956 PSU.

Water sample salinities were compared with CTD salinity profiles to identify outliers. Differences greater than 0.01 PSU were flagged for further examination at depths shallower than 450 m. Below 450 m, differences greater than 0.005 PSU were flagged. Due to possible flushing effects through steep gradients, exceptions were made if the sample value was vertically within 5 m of the CTD profile (accepted as good values) or within 10 m (flagged as questionable values).

2.4.1.2 Dissolved Oxygen

Following the cast, once the Niskin bottle integrity was checked, samples were drawn for CFCs and then dissolved oxygen. Water was drawn through rubber tubing into a calibrated (volume) glass flask with attached stopper. The sample was immediately pickled with 1.0 mL of manganous chloride then 1.0 mL alkaline iodide, the stopper inserted and the flask shaken to mix the contents. The flask was stored in the refrigerator until analysis.

Analysis

Dissolved oxygen samples were analyzed on board by Mary Steel within 24 hours of collection using an automated version of the Micro-Winkler Technique as described in Carpenter (1965). The methodology follows standard IOS protocol described by Minkley and Chase (1997). All chemical solutions were prepared at IOS. The titration was performed with a Metrohn Dosimat 665 and the end point was detected using a Brinkmann probe colorimeter PC910 SN910-358. Software, written at IOS (NewAutoOxy.exe), was used to calculate dissolved oxygen (mL/L).

A problem with the titration software occasionally caused the program terminate the titration prematurely. The software was restarted, the titration completed and the volume of titrate used in the two runs was summed.

Standards and Accuracy

Standards and blanks were measured whenever a new bottle of reagent and/or sodium thiosulfate or potassium iodate was opened. Subsequent analyses used these new values to calculate oxygen concentration.

The pooled standard deviation was $s_p = 0.022$ mL/L, from 87 pairs with 2 outliers removed.

Deep water samples, from depths greater than 2950 m in the homogenous bottom water were found to have a mean of 6.55 with a standard deviation of 0.017 from 29 samples.

Oxygen samples were compared with CTD oxygen profiles to identify outliers. At depths shallower than 500 m, differences greater than 0.1 mL/L were examined and flagged if no reason for the difference could be found. Below 500 m, the data were flagged as bad and not reported if differences were greater than 0.05 mL/L. As with the salinity samples, due to possible flushing effects through steep gradients, exceptions were made if the sample value was vertically within 5 m of the CTD profile (accepted as good values) or within 10 m (flagged as questionable values).

2.4.1.3 Nutrients

Sampling

Water samples for nutrient determination were collected into acid-washed glass and polystyrene test tubes after the tube and cap had been rinsed three times with the sample water. Samples from the first four stations, collected in the Canadian Arctic Archipelago, were frozen and subsequently analyzed during the cruise. Samples from the last four stations were frozen and analyzed at the Institute of Ocean Sciences using the same method. If analysis could be performed within 24 hours the samples were stored at 4 °C, if not they were frozen at -20 °C.

Analysis and Results

Nutrients (nitrate, silicate and phosphate) were analyzed by Linda White onboard ship using a three channel Technicon Auto Analyzer, following the methods described by Barwell-Clarke and Whitney (1996). Reagents were prepared onboard using water from a NANOpure system that produced 17 to 18 mega ohm-cm resistance Type I reagent grade water. The system was supplied with ship's distilled water. A 3.2% weight-to-volume solution of sodium chloride (Sigma, after 2003) was prepared daily and used to rinse the system between samples and to prepare working standards. Pump tubing was changed after approximately 500 samples. One cadmium column was used for all samples unless noted below. The Auto Analyzer was cleaned every other day as follows; rinsed with 3N NaOH first and then 10% HCl for approximately 5 minutes and rinsed with DMQ for over 20 minutes after all reagents and salt were disconnected at the end of the day. Data were logged both by analog (chart) and digitally using the IOS "Newget" program.

Standards and blanks

NANOpure water was analyzed daily before connecting the reagents and analyzing the initial standards and after the last set of standards to establish the baseline and record the purity of the reagents. A set of working standards (low, medium and high) were prepared from the stock standard solution, using freshly prepared 3.2% sodium chloride (Anachemia) solution. The stock solutions were prepared from: Potassium nitrate (Fisher); Sodium silicofluoride (Fisher); and Dihydrogen potassium phosphate (BDH Aristar). The working standards were analyzed at the start and close of each day or, if more than 60 samples were to be analyzed in a day, standards were also run mid-day or after three hours Concentrations of the standards were selected to bracket the expected nutrient levels in the samples. A medium standard for each nutrient was analyzed between stations consisting of 12 to 27 samples and as an unknown sample followed by two zero standards.

Standards purchased from Wako (0 µm/L and 20 µm/L nitrate and 0 µm/L and 50 µm/L silicate) and Reference Samples (RS) purchased from KANSO (AS and AT) were analyzed at the end of each day. See below for specific details. An onboard reference sample was collected at sea, stored at 4 °C in the dark, and analyzed daily to provide an operational check.

The order of the sample analysis was from the surface to depth and sample peaks that appeared to be out of order were re-analyzed. Duplicate samples were collected approximately every 10 samples. One sample from every cast was collected in triplicate with two samples analyzed the day of sampling and the third sample analyzed the following day to verify the day-to-day calibrations. The results of the replicate and standards comparisons are listed below.

The turbidity of surface samples where salinity is less than 27 PSU were analyzed through the phosphate channel with no reagents being added to the sample. When the nitrate level in surface samples was the same or slightly lower than the 3.2% sodium chloride solution it was reported as zero.

See Table 9 below for nutrient quality control and assurance information.

Table 9. Quality control and assurance for nutrient samples.

Nutrient	**Nitrate + Nitrite (mmol/m^3)**	**Silicate (mmol/m^3)**	**Phosphate (mmol/m^3)**
Sample Replicates			
s_p	0.08	0.10	0.01
No. of duplicates	93 out of 94	92 out of 95	94
S_p of Casts 1-4 frozen	0.04	0.06	0.03
No. of duplicates	23 out of 24	24	24
Medium check standard – (Analyzed as unknown)			
Calibrated value	16.0	40.0	2.01
Average and std dev	16.0 ± 0.1	40.0 ± 0.2	2.02 ± 0.02
No. of duplicates	17	15	16
Wako Standard	20.0 ± 0.09	49.9 ± 0.2	n/a
No. of duplicates	6	6	
KANSO AS (low)	0.08 ± 0.04	1.70 ± 0.08	0.05 ± 0.01
No. of duplicates	6	7	10
KANSO AT (high)	7.5 ± 0.1	18.3 ± 0.1	0.58 ± 0.01
No. of duplicates	12	12	11
Onboard reference CB28B			
Average	16.1	40.1	2.01
Stdev	0.1	0.3	0.02
n	17	15	15

2.4.1.4 Oxygen Isotope Ratio ($\delta^{18}O$)

Sampling

Samples were drawn from the Niskin into 30 mL glass vials following three rinses of the vials with sample water. Once at room temperature the caps were retightened and wrapped with parafilm for storage until analysis back onshore.

Analysis

Samples were analyzed using a mass spectrometer connected to a H_2O-CO_2 equilibration unit. The oxygen isotope composition is referenced to Vienna-Standard Mean Ocean Water (V-SMOW):

(V-SMOW): $\delta^{18}O = ((H_2{}^{18}O/H_2{}^{16}O)_{sample} / (H_2{}^{18}O/H_2{}^{16}O)_{VSMOW} - 1) \times 10^3$ [‰].

The obtained "raw" $\delta^{18}O$ values are normalized using internal laboratory standards, which was calibrated periodically using international standards (VSMOW, SLAP, GISP).

230 samples were analyzed in December and January, 2006, at Oregon State University (OSU) by William Rugh using the H_2O-CO_2 equilibration method on a Thermo Finnigan DeltaPlusXL mass spectrometer. Internal standards used at OSU were LROSS, NaHCO3, row, and W9809A.

114 samples were analyzed at JAMSTEC by Kazuma Tamura using the MAT 252 mass spectrometer. Internal standards used at JAMSTEC were DKWJ, Dome, and JMSW.

Precision of analysis calculated based on sample replicates was s_p = 0.24‰ (n = 14) for samples analyzed at JAMSTEC (s_p = 0.08‰, n = 11 when 3 anomalous values were excluded) and s_p = 0.06‰ (n = 28) for samples analyzed at OSU. For all samples, s_p = 0.15‰ where n = 42 (or s_p = 0.07‰, n = 39 when 3 values were excluded).

2.4.1.5 Barium

Barium samples were drawn from the Niskin into small plastic vials following three rinses of the vials. Once at room temperature the caps were retightened. Barium concentrations were determined at Oregon State University by Christopher Guay on a VG Thermo Excel inductively coupled quadrupole mass spectrometer. An isotope dilution method was used as described in Falkner et al. (1994) with minor modifications. Briefly, 250 μL aliquots of sample were spiked with an equal volume of a ^{135}Ba-enriched solution (Oak Ridge National Laboratories) and diluted with 10 mL of 1% HNO_3. The spectrometer was operated in peak jump mode, and data were accumulated over three 20 s intervals for masses 135 and 138. Based on replicate analyses of samples and standardized reference materials, the precision (2-sigma) of the analytical procedure ranges from < 5% at 10 nmol/L Ba to < 3% at 100 nmol/L Ba. Duplicate samples were used to determine precision: s_p = 2.56 μmol/m^3; n = 44 pairs after one outlier removed.

2.4.1.6 Dissolved Inorganic Carbon

Sampling

Seawater was transferred to a glass sample bottle (250 or 500 mL) as soon as possible after the rosette cast to minimize gas exchange. The sampling tube was connected to the spigot of the Niskin bottle and, by holding the tube above the spigot, was rinsed by flowing approximately one tube volume of sea water through the tube. Any trapped air bubbles were removed by tapping or squeezing the tube. The bottle was filled smoothly from the bottom (tubing touching the bottom of the bottle) and the bottle overflowed by two times its volume. The tubing was withdrawn to the neck and the spigot valve closed or the flow in the tubing squeezed off before the tubing was removed from the bottle. One percent of the stoppered sample volume was removed to leave a headspace (about 1% of the bottle volume -- i.e., 5 mL for a 500 mL bottle) by inserting a nylon plug into the bottle. A volume of 100 µL of saturated mercuric chloride solution ($HgCl_2$) was added to the bottle (both 250 mL or 500 mL). A greased stopper was inserted and sealed with elastic bands or electrical tape. Samples were stored at 4 °C until analysis back onshore. DIC then alkalinity were measured from the same sample.

Analysis

Samples were analyzed at IOS by Marty Davelaar using a SOMMA (Single-Operator Multi-Metabolic Analyzer) - Coulometer system to determine the concentration of dissolved inorganic carbon (or total carbon dioxide). The SOMMA is a sea-going, computer-controlled automated dynamic headspace analysis, constructed at IOS by Ken Johnson (University of Rhode Island) and Keith Johnson (IOS). The current design of the SOMMA system is similar to the one described by Johnson et al. (1993). The SOMMA is interfaced with an IBM compatible computer and a coulometric detector (UIC Coulometrics, model 5011). The SOMMA dispenses and acidifies a known volume of seawater, strips the resultant CO_2 from solution, dries it and delivers it to the coulometric detector.

At the start of each day, seawater was run through the system to condition the cell. Once the system appeared to be working well, standard water or a known sample was run to confirm proper operation. For each analysis (standard or sample) CO_2 in nitrogen was used to push liquid out of the sample bottle and into the water-jacketed calibrated pipette. The water from the pipette was then drained into a scrubber compartment to which approximately 0.5 mL of 8.5% ortho-phosphoric acid had been added. The CO_2 was stripped from the water by the acid and then passed into the coulometer cell where it was measured. The coulometer was operated in the µg C mode. Using the SOMMA software, this mode takes the coulometer's voltage to frequency converter output along with constants supplied by the user and calculates µmol *C* titrated. For each sample or standard, the analysis was run twice. The first analysis was considered a rinse and the second analysis the final value. The final concentrations are calibrated with the daily measured standard where:

$$\text{corrected value} = \frac{\text{(raw value * measured standard)}}{\text{(standard value * correction for mercuric chloride volume)}}$$

The mercuric chloride correction is either 1.0002 or 1.0004, depending on whether the sample volume was 250 or 500 mL. DIC values are reported in units of µmol/kg.

Standards, blanks and precision

The accuracy of DIC analysis was assured by daily analysis of IOS standard sea water (batch 13, concentration 2088.35 µmol/kg) which had been calibrated using certified reference material (batch 73 with a concentration of 2057.3 µmol/kg) (DOE 1994; Dickson 2001; Dickson et al. 2003) supplied by Andrew Dickson (Scripps Institute of Oceanography, San Diego, USA). The difference between the measured value and calibrated value of the IOS standard seawater was less than ±1 (0.05%).

Precision is given by the pooled standard deviation of sample replicates. $s_p = 1.52$ µmol/kg, where $n = 6$ pairs (two outliers removed).

2.4.1.7 Alkalinity (Paired with DIC)

Sampling

Alkalinity was measured from the same sample collected for DIC. Please see the DIC section for the sampling method.

Analysis

Samples were analyzed at the Institute of Ocean Sciences (IOS) by Marty Davelaar using an automated potentiometric titration system to determine the total alkalinity. The pH was measured using a Ross combination electrode. Acid was dispensed with a Dosimat 665. A program written by the University of Hawaii was used to control the Dosimat.

At the start of each day, seawater was run through the system to condition the instruments. Once the system appeared to be working well, standard water was run to confirm proper operation. For each analysis (samples and standard), a known amount (~75 grams) of sample was weighed in an open beaker. An initial amount of 0.7N (0.6N NaCl, 0.1N HCl) acid (IOS batch 3, concentration 0.09676), was added to the seawater to take its pH to approximately 3.5. The acid volume was adjusted depending on the salinity of the sample such that the initial pH was near 3.5 to allow the full titration between 3.5 and 3.0 to be performed. After an eight minute period in which CO_2 was stripped from the seawater, 0.025 mL aliquots of acid were added to the seawater until a final pH of approximately 3.0 was obtained. The University of Hawaii program was used to calculate the alkalinity of the seawater by use of a Gran plot. The final concentrations are calibrated with the daily measured standard where:

$$\text{corrected value} = \frac{\text{(raw value * measured standard)}}{\text{(standard value * correction for mercuric chloride volume)}}$$

The mercuric chloride correction is either 1.0002 or 1.0004, depending on whether the sample volume was 250 or 500 mL. Alkalinity values are reported in units of µmol/kg.

Alkalinity (from DIC bottle) is higher compared to data from other cruises. Mean alkalinity value for waters in 500 to 1050 m layer is 2293.0 µmol/kg based on recent and more reliable measurements from LSSL2005, LSSL2008 and Mirai2008. For LSSL2005-04, mean alkalinity for the same layer is 2319.97 µmol/kg. Alkalinity data in the Final Chemistry spreadsheet are corrected values for this difference by multiplying $f = 0.98837$ (2293.0/2319.97).

Standards and precision

The accuracy of the alkalinity analysis was assured by daily analysis of certified reference material (batch 73, concentration of 2253.5 µmol/kg) (DOE 1994; Dickson 2001; Dickson et al. 2003) supplied by Andrew Dickson (Scripps Institute of Oceanography, San Diego, USA).

Precision is given by the pooled standard deviation of sample replicates. $s_p = 2.43$ µmol/kg, where $n = 7$ pairs (one outlier removed).

2.4.1.8 Alkalinity (Not Paired with DIC)

Seawater samples were collected from Niskin bottles into 500 mL glass bottles with screw caps for alkalinity measurements. 408 water samples from 28 stations were collected and stored in the fridge until ~1 hour before analysis. Samples were analyzed on board the vessel within 48 hours after sampling by Michiyo Yamamoto-Kawai. One third of samples were analyzed in replicate. Samples from the last several stations were stored in the cooler, with $HgCl_2$ added to prevent biological activity, to be analyzed back onshore. The total alkalinity was determined by potentiometric titration using 0.1 N HCl with a Brinkman Dosimat 665, a Ross combination pH electrode, and an Orion pH meter model 725A. The Dosimat was controlled using a program written by the University of Hawaii.

The sample was weighed (~75 g) prior to analysis for onshore analysis. For on board analysis, a constant volume of sample or standard water was collected using a pipette and put into an open beaker. Pipette and sample bottles were kept at 4 °C in a water bath prior to analysis. Room temperature, used as acid temperature, was read by a digital thermometer mounted next to the alkalinity system. An initial amount of 0.1N HCl was added to the seawater to take its pH to approximately 3.5. Then, 0.025 mL aliquots of acid were added to the seawater until a final pH of approximately 3.0 was obtained. The University of Hawaii program was used to calculate the total alkalinity of the seawater by use of a Gran plot. A nominal weight of 100.55 g was used as an input value into the PC program for alkalinity calculation, which was determined by a "practical method" to obtain the assigned value of 2280.33 µmol/kg of IOS standard water (IOS-STD). The IOS-STD alkalinity was determined against the certified reference material supplied by A. Dickson, Scripps Institute of Oceanography.

Obtained "raw" values of the samples were then corrected for density differences by using:

T_Alk [µmol/kg] = T_Alk [raw] * density [STD] / density [sample]

where density of the IOS-STD at 4 °C is 1026.9 kg kg/m^3. IOS standard water was measured daily before the sample measurements.

Standards and precision

The average concentration of IOS-STD was 2279.72 ± 4.66 µmol/kg; n = 56 for the on board analysis and 2277.33 ± 2.39 µmol/kg; n = 39 for onshore analysis.

A plot of total alkalinity measurements vs. CTD-salinity was made simultaneously during analysis, and samples that seemed unusual in the plot were re-analyzed. In addition, a couple of samples were randomly chosen for each station and analyzed in duplicate. Pooled standard deviation for replicate analysis was s_p = 9.7 (n = 118). During the on board analysis, there were problems with the software or computer: the system stopped during titration. This happened 172 times during the cruise and required to restart the program and Dosimat, and extra measurements.

2.4.1.9 Chlorophyll-a and Phaeopigment

Chlorophyll-a and phaeopigment methods follow the general procedure reported by Strickland & Parsons (1972) and by Arar & Collins (1997). The analysis was performed primarily by Ryan North and overseen by Linda White.

Sampling and Filtration

Prior to the cruise, brown Nalgene sample bottles (500 mL, 1L or 2L), were acid cleaned with 10% hydrochloric acid, rinsed twice with de-ionized water, then rinsed with double de ionized water, air dried and capped. Water samples were taken last from the Rosette to ensure there was enough water for all other samples. To collect a seawater sample the bottles were rinsed 3 times, filled to the brim or a calibration mark and capped. The 2 L bottles (ranging from ~2000 mL to ~2180 mL) were immediately placed in dark bags and, at the end of sampling, transported to a fridge in the nets laboratory.

As time permitted, the samples were filtered onto 25 mm glass fiber filters (Whatman GF/F; 0.7 µm pore size) under 5 psi vacuum and placed in clean scintillation vials. The volume of sample filtered was recorded. The area around the filtration setup was maintained under very low lighting and the actual filtration apparatus was covered with dark plastic. The sides of the castle were not rinsed (in case the cells lysed and contents passed into the filtrate).

Extraction

Initially, 10 mL of 90% Acetone was added to the filters in scintillation vials immediately after sampling. However, with increasing rosette casts the timing for reading the values was difficult. Thus, after filtering, the filters were preserved in the -20 °C freezer in scintillation vials before 90% acetone was added at a more convenient time.

Once the acetone was added, the vials were shaken vigorously and placed in a tray along with two filter blanks and the samples were left to sit for 24 hrs in the -20 °C freezer. The samples were allowed to adjust to room temperature for ~1 hr before being read with the fluorometer.

Measurement

Fluorescence was measured using a Turner Designs 10 AU - 005 Field Fluorometer (s/n 5152 FRXX) calibrated with Sigma C6144 – 1 mg Chlorophyll a extracted from *Anacystis nidulans* algae on February 17, 2005 by Linda White. A solid standard was measures at the beginning and end of each day of analysis to validate the instrument operation.

Samples were removed from the freezer in small batches to equilibrate for 1 hour in the dark and in the same lab as the fluorometer. The sample extracts were transferred to clean borosilicate test tubes without disturbing the filter paper. The tube exterior was wiped clean and placed in the Turner 10 AU Field Fluorometer sample holder making sure the sample cover was in place. Once the reading stabilized the chlorophyll a fluorescence (Rb) was recorded. The extract was then acidified by the addition of 2 drops of 1N HCl and the phaeopigment fluorescence (Ra) was recorded. If the fluorescence was over range the samples were diluted with 90% acetone and re-read, with the dilution factor being recorded. Filter blanks, consisting of a filter placed directly into a scintillation vial, were measured in the same manner as the samples.

Clean borosilicate test tubes were used for each sample eliminating possible sample to sample contamination of acid. Borosilicate tubes were cleaned with 10% solution of Extran, rinsed thoroughly with hot water with a final rinse of double de ionized water, air dried and re-used.

Standardization

Purified Chlorophyll a (Sigma) was dissolved in 500 mL of 90% acetone/10% double de-ionized water in a volumetric flask. The flask was wrapped in foil to keep the standard in the dark and stored in a freezer.

The primary stock standard was scanned using a Cary spectrophotometer to determine the chlorophyll a concentration. A series of standards, encompassing the range of sample concentrations, were prepared by dilution with 90% acetone/ 10% double deionised water and analyzed on the fluorometer the same day at IOS. A linear regression was calculated and used to determine sample concentrations. These calculations were performed in a spreadsheet that included volume filtered, volume of extract and fluorescent values and formulae for chlorophyll a and phaeopigment calculations.

Chlorophyll data processing

Chlorophyll estimates and phaeopigment estimates were calculated following the procedure in JGOFS manual (1994). The basic equations used were as follows:

$$\text{Chl } (\mu\text{g L}^{-1}) = (F_m/F_m\text{-}1) \text{ x } (F_o\text{-}F_a) \text{ x } K_x \text{ x } (Vol_{ex}/Vol_{filt})$$

$$\text{Phaeo (chl eqiv. wts)} = (F_m/F_m\text{-}1) \text{ x } [(F_m{*}F_a)\text{-}F_o] \text{ x } K_x \text{ x } (Vol_{ex}/Vol_{filt})$$

Where:

F_m = acidification coefficient (F_o/F_a) for pure chl (usually ~2)
F_o = reading before acidification
F_a = reading after acidification
K_x = door factor from calibration calculations (use 1.0)
Vol_{ex} = extraction volume (usually 10 mL acetone)
Vol_{filt} = sample volume

The lab fluorometer (Turner Model 10 Field Fluorometer MEHS) used on the ship experienced a calibration shift during its transit from our lab at IOS to the ship. The solid standard with its two values (F_o of approximately 14 and 80) is used to track the stability of the instrument.

There was a single change in the solid standard readings recorded before the cruise and during the cruise. The readings recorded back at IOS after the cruise are the same as the "at-sea" readings.

The solid standard shift was reduced by 9%. A short calibration (to known chlorophyll concentrations) was performed after the cruise. The pre to post cruise calibration using known chlorophyll concentrations only showed a 2.5% change (lower) in concentrations. Chlorophyll measurements have an associated 10% error (Turner method 445.0), thus the difference is not exceptional.

The data were corrected to the post-cruise calibration.

Filter blanks:
0.004 ± 0.01 μg Chla per filter, $n = 5$
0.00 ± 0.00 μg Phaeopigment per filter, $n = 3$
It appears no filter blanks were analyzed.

Duplicate samples were used to determine precision:
$s_p = 0.006$ mg/m^3 Chla , $n = 22$, range: 0.0 – 2.4 mg/m^3
$s_p = 0.020$ mg/m^3 Phaeopigment, $n = 22$, range: 0.01 – 0.98 mg/m^3

Note: Errors due to missed volume measurements, not using the fluorometer lid etc. are listed in the spreadsheet and logbook.

2.4.1.10 Bacteria

Phytoplankton and bacterioplankton samples collected for Dr. Bill Li (Bedford Institute of Oceanography - BIO) by William Burt (IOS) were preserved in aliquots of seawater sampled from the Niskin bottles. Following standard protocol (Marie et al. 1999), 1.8 mL seawater was dispensed into a 2 mL capacity cryogenic vial and immediately fixed with 0.2 mL of 10% paraformaldehyde by vortex mixing. Samples were maintained for at least 15 min at laboratory temperature to allow fixation, and then stored at -80 °C until analysis at BIO.

Cell concentrations of picophytoplankton, nanophytoplankton, and bacterioplankton (i.e. non-autofluorescent picoplankton) in thawed samples were analyzed at BIO by flow cytometry (Becton Dickinson FACSort) following protocols in routine use (Li & Dickie 2001). Phytoplankton were detected by native autofluorescence using blue laser excitation (488 nm) and long-pass red emission (>650 nm). Cells smaller than 2 µm equivalent spherical diameter were classified as picoplankton and those larger as nanoplankton. In turn, picophytoplankton were partitioned into two groups according to the presence (cyanobacteria) or absence (picoeukaryotes) of the pigment phycoerythrin detected in the orange waveband (585 ± 21 nm). Bacterioplankton were stained with SYBR Green 1 (Molecular Probes, Oregon), a nucleic-acid binding fluorochrome, and detected in the green waveband (530 ± 15 nm). Measurements of fluorescence and light scatter were collected using logarithmic amplification and recorded in relative units in a 4-decade range spanned by 256 channels. Fluidic flow rate was calibrated by regression of the aspirated volume versus duration of analysis. Data were extracted from listmode format using WinMDI Version 2.8 (copyright Joseph Trotter, http://facs.scripps.edu/).

Note: Data from Mission 2004-16 are also reported in **Appendix 5**.

2.4.1.11 Radionuclides (Iodine 129 and Cesium 137)

Sampling and Analysis

Seawater samples were collected using 10 L Niskin bottles attached to a rosette system.

Seawater samples for ^{129}I analyses were collected into 1 L PVC bottles that had been pre-rinsed with seawater to remove any foreign debris. Samples were returned to John Smith at the laboratory of the Atlantic Environmental Radioactivity Unit (AERU) at the Bedford Institute of Oceanography (BIO). In the laboratory, a NaI carrier was added to a 200 mL aliquot of the seawater sample, it was slightly acidified, purified using multiple hexane extractions and iodine was precipitated as NaI. The NaI precipitate was shipped to the IsoTrace Laboratory at the University of Toronto where ^{129}I analyses were performed by accelerator mass spectrometry (Smith et al. 1998; 1999; 2005). The sample data were normalized to the IsoTrace Reference Material #2 ($^{129}I/^{127}I = [1.313 \pm 0.017] \times 10^{-11}$ atom ratio) which is calibrated using the NIST 3230 I and II standard reference material. The blank (KI carrier added to distilled and deionized water) for this procedure is $0.75 \pm 0.10 \times 10^7$ at/L and the standard deviation (one sigma) ranged from 5 to10% (Edmonds et al. 1998). ^{129}I concentrations in seawater are generally expressed in units of 10^7 atoms/litre. IsoTrace has participated in a number of ^{129}I International intercomparison exercises, including the NIST SRM 4359 Seaweed, the Lawrence Livermore ^{129}I intercomparison, phases I and II and the IAEA-0375 Radionuclides in Soil intercomparison. IsoTrace ^{129}I procedures and sample handling protocol have been approved by the United States Office of Civilian Radioactive Waste Management, through on-site inspections by Bechtel SAIC Inc.

Approximately 20 to 30 L of seawater were collected into 10 L plastic carboys for ^{137}Cs analyses. The water samples were passed through a potassium ferrocyanide (KCFC) packed resin column in the laboratory which quantitatively extracts ^{137}Cs from seawater (Smith et al. 1990; Smith & Ellis 1995). A second column was occasionally aligned in series to confirm that extraction efficiencies for ^{137}Cs were close to 100%. The KCFC resin was deployed in a standard geometry and measured using a hyperpure Ge detector having an efficiency of 25%. ^{137}Cs concentrations in seawater are expressed either as Bq/m^3 or mBq/L. Numerous analytical intercomparisons (including publicly reported blind exercises) have been carried out with other laboratories by the (AERU) over the past 30 years for quality assurance purposes. Intercomparison samples have been provided by the United States Environmental Protection Agency (USEPA), the United States Environmental Measurements Laboratory (EML) and the United States Department of Energy as part of their Mixed Analyte Performance Evaluation Program, MAPEP. Marine environmental samples (eg. IAEA-315; IAEA-326; IAEA-327) provided by the IAEA (International Atomic Energy Agency) have been analyzed to insure compliance with international standards in the marine radioactivity community. NIST (National Institute of Standards and Technology) ocean and river sediment reference materials are analyzed on the detectors on a regular basis as a calibration check.

2.4.1.12 Halocarbons: CFC-11, CFC-12, CFC-113 and CCl_4

Halocarbons were sampled at 26 of the 34 stations. Three stations were sampled in high resolution from approximately 300 to 500 m to investigate intrusions.

Analysis and Results

Halocarbon samples were the first to be drawn from the Niskin following the Niskin bottle integrity checks. The sample was collected in a Perfektum 250 mL glass syringe (Popper & Sons Inc.). Syringes were rinsed three times with sample water and filled, taking care not to allow air bubbles enter the syringe. Syringes were submerged in a bucket or sink filled with cold seawater until analysis to prevent contamination from the high CFC concentration in air.

Analyses for CFC-12, CFC-11, CFC-113, and CCl4 were carried out by Nes Sutherland and Wendy Richardson on the IOS automated purge and trap system. Separation and detection of the components was achieved using a 60 m, 0.32 mm GasPro G fused silica column and a Hewlett Packard GC/Electron Capture Detector, respectively. Standardization was done using a gas standard (S14) prepared at Brookhaven National Laboratories and standardized at Scripps Institute of Oceanography according to the SIO1998 scale. Air samples were taken as a further check on the operation of the system.

The daily routine for CFC analysis is summarized below:

1. Changed water trap and ran a blank until peaks were normal – usually by the second run.
2. Woke-up the instrument by running 2 x 15 mL calibration gas injections or two surface seawater samples.
3. Ran the calibration curve, highest to lowest.
4. Ran a blank.
5. Ran a 6 mL standard.
6. Ran 8 seawater samples – included 1 atmosphere sample and at least 2 duplicates per station.
7. Changed water trap.
8. Repeated 4-7 as necessary.
9. When the sample run was finished:
    a) ran a blank and a 2, 6 and 12 mL standard or
    b) if the unit was in continuous use, ran a complete calibration curve.

With this routine, about 65 injections per 24 hours could be made, including about 40 water samples. The trap and GC were baked out for about two hours each (at the same time) once per week or when needed. Mol sieves were baked out at the start of the cruise and only again if there were signs of contamination.

Initial problems during start up delayed the analyses of samples from the first few stations. A new air injection valve was inserted, but was discovered to absorb CCl_4 and, subsequently, was removed. Another problem was the low flow rate coming out at the exhaust of the valve extraction board (Vex). This was traced to a leaky rotor in valve 3, which was then replaced. The 1/16" line from the $Mg(ClO_4)$ trap to the top of the purger clogged, requiring the eventual replacement with 1/8" line. After these initial problems were resolved, a helium check of the system confirmed there were no leaks and the system was operable.

Mid-cruise there were problems with unstable flow rates. A few leaks were sniffed out with He, but tightening these did not really help. Pushing the cone down over a small cracked section on the top of the purger column on August 17^{th} helped to improve flows and response slightly but only temporarily to August 23^{rd}. Running a high standard through various parts of the system, bypassing other parts revealed that there was a major leak. During the ship's week long down time, the system was taken apart, a new purger tube inserted, and broken glass bits that had cracked off the base of the old one were removed. Test calibration run on the 23^{rd} indicated there were still problems. It was discovered that the V3 rotor was scratched and some gas would flow out the water drain at position 2. This rotor was once again replaced, and from then on, the system worked very well. Towards the end of the trip, the zero started climbing, but never reached significant levels fortunately as there was not enough time for a bakeout.

The stations most affected by these leaks were CB9 (some), all CB10, CB12 and CB13 and therefore no CFC data are reported from these stations. There were also problems with the standard calibration for carbon tetrachloride and the data where this occurred are not reported.

See Table 10 below for water sample precision.

Standards, blanks and precision

Table 10. Water sample precision.

	s_p	*n*
CFC-12	0.03 nmol/m^3	39
CFC-11	0.09 nmol/m^3	39
CFC-113	0.03 nmol/m^3	39
CCl_4	0.31 nmol/m^3	39

2.4.1.13 Halocarbons sampled in Ampoules

All CFC's were analyzed at sea, but a window of opportunity opened near the end of the cruise that allowed time to store a few random replicate samples in glass ampoules for analysis onshore.

The ampouling equipment was set up on a bench in the rosette lab. A UHP N2 tank was tied against the wall, and the trap baked out for ~ 2 hours prior to use. Ampouling was accomplished as per John Harris's instructions, except that ~25 mLs sample rather than 20 mLs was syringed into the ampoule, after three rinses. The sealing was performed smoothly and rapidly with the assistance of the students having the torching equipment ready to go.

The samples were collected as per normal CFC methods, at the same time as the onboard CFC samples were taken. Those taken at Cast 045 were stored in the water bath for ~6 hours until the ampouling system was set up. For Cast 046 three people sampled CFCs: two to collect syringes for the onboard CFC system and one to collect and immediately ampoule replicate samples.

In all, 13 ampoules were successfully sealed, of these 4 sets were duplicates, the others single, and two syringes were broken. The ampoules were wrapped in tissue and stored at 4 °C for transport back to IOS. These samples have not been analyzed to date (January 2010). See *Canadian Data Report of Hydrography and Ocean Sciences 184* for details on ampouler system.

2.4.1.14 Total Organic Carbon

Sampling

Unfiltered samples were drawn from Niskin bottles without tubing, into precleaned and rinsed 40 mL glass vials with Teflon-Si rubber septa. All were frozen at -20 °C, except for one of the duplicated sets (Stn CB9) that was acidified and stored at 4 °C. The acidification was by pipette addition of 200 µL 21% H3PO4, ACS grade, to each vial, after all samples were collected.

At the last TOC cast, Stn CB18, 28 TOC vials were filled with water from Niskin #3 to be used during analysis as a Daily Reference Standard. These were frozen along with the others.

Total Organic Carbon (TOC) samples were collected from 4 stations:

Cast 20 – Stn CB4 – 24 Niskins, with duplicates from 2 random depths
Cast 28 – Stn CB9 – 24 Niskins, 2 complete sets, with duplicates, to compare storage methods
Cast 39 – Stn CB15 – 24 Niskins, with 2 sets of duplicates
Cast 43 – Stn CB18 – 24 Niskins, with 2 sets of duplicates

Analysis

Samples were analyzed at IOS by Nes Sutherland using High Temperature Catalytic Oxidation, using a Tekmar Dohrman Apollo 9000HS (High Sensitivity) analyzer with an NDIR (Nondispersive Infrared) detector, and STS 8000 Autosampler. Instrument parameters were set to 680 to 700 °C furnace temperature, using Pt over TiO_2 catalyst, 4 minute sparge of ~10 mL sample treated with 200 µL of 21% H_3PO_4. Actual sample injection size was 200 µL. The samples were analysed in five separate data sets, each data set lasting 3 to 5 days.

Standards of potassium biphthalate solution (Tekmar Dohrman 1000 µg/mL stock) were prepared directly into the TOC vials, for calibration runs performed at the beginning, middle and end of sample sets. Recirculated Milli-Q (RmQ) was used for Low Carbon blanks and drift calculations. Daily Reference Standards (DRS), prepared from bulk water collected either from deep water in the north Pacific or the Arctic Ocean, were also used to monitor drift and response changes. In addition, Certified Reference Material (CRM), obtained from Hansell Labs in Florida were analysed daily. Typically, an analysis set would start with warm-up blanks and seawater samples until the system was stable, then standards would be run, blanks compared with the Hansell Low Carbon water, followed by samples. Samples would be run in a series of 1 to 2 blanks, followed by a DRS, then 5 samples (each with 5 injections), and so forth. Bermuda Sea Water CRMs were inserted daily, following a DRS.

Determining blanks is notoriously difficult in DOC analysis. The Apollo system has a program that cleans the RmQ through the column, and then reinjects it to provide a system blank; however, this is best done at the start of an analysis run, as the injection of larger quantities of RmQ appears to wash more accumulating salts from the top of the column into the catalyst, creating problems. RmQ blanks are compared with the system blanks, and if very different, the system is further cleaned, and the RmQ recirculated for a longer period of time before retesting. For one analysis set, the RmQ blanks did not clear up, and instead the Low C CRM was used as a blank correction. The frequent use of RmQ blanks allows for continual monitoring and subsequent correction of drift and seawater carryover that can occur when very high organic samples are introduced. These blanks have been found to be approximately the same as the blank that would be predicted by using the calibration slope and expected CRM DOC content.

For each sample, all peaks were manually scanned for baseline or peak irregularities, and only the area of acceptable peaks was averaged. To calculate sample concentration, blank values were subtracted, then the calibration curve regression applied. Replication within an individual vial resulted in an overall average of RSD = 4.2%. Replication using separate vials resulted in an overall average RSD = 4.7%, or s_p of 2.7 µM. Elimination of one grossly differing pair brought the s_p down to 1.9 µM. The CRM Bermuda Deep 12-00 averaged 46.1 ± 2.7 µM over the five analysis sets. The Low Carbon CRM averaged -0.6 ± 1.1 µM. See Table 11 below for notes on TOC analysis sets.

Table 11. Total Organic Carbon Analysis Sets

Analysis Set No.	Station	Sample No.	Notes
082007	CB4	1-24	This set started with 2 days of cleaning the Apollo system until it stabilized. The RmQ blanks were still a bit high at the start, likely due to the use of the alternate water system, as the usual one was at sea. After running the RmQ system all day, the blanks did come down. For the first samples, the Low C CRM values were used as a blank correction. A few samples, #7,9,10&12, however, were further burdened with somewhat higher integration times, and are less reliable.
082907	CB9	1-18	This set started fine, but integration times began to rise, with no obvious contributing factors. The run was cut short, and the samples rerun in the next set.
090107	CB9 CB18	5-24 1-24	This analysis set ran very well, no problems encountered. CB9 samples were rerun, starting at #5 – sample duplication was good with those run in 082907 until integration times started changing in the earlier run.
102907	CB15	1-24	This analysis set ran very well, no major problems encountered. Blanks were a bit higher than normal at start but gradually came down smoothly with time.

2.5 OTHER FIELD SAMPLING

Short summaries of additional data collected but not included in this report are given below.

2.5.1 LADCP

Waldemar Walczowski, Institute of Oceanology Polish Academy of Sciences, Poland, made ocean current measurements using a Lowered Acoustic Doppler Current Profiler (LADCP). Data were collected on each CTD cast. The self recording RDI, 307.2 kHz device SN 3313 was attached to the rosette frame. The downward-looking LADCP measured currents in 20 depth cells, each cell (bin) 10 m thick. In the vicinity of the bottom, bottom tracking was used. Vertical decent rate of the rosette was always less than 1 m/s. LADCP data were read directly after profiling. Additionally CTD records were used to determine the ship position (from NMEA protocol registered every scan) and LADCP depth (from CTD pressure and time records). LADCP data were processed using LDEO software. 42 LADCP casts were performed. See **Appendix 8** for detailed LADCP report and data.

2.5.2 XCTD

An XCTD (eXpendable Conductivity Temperature and Depth) survey was conducted by Masuo Hosono (JAMSTEC), from the stern of the ship using a hand held launcher. The XCTD probes were provided by Koji Shimada (JAMSTEC) (Type XCTD-1 made by Tsurumi Seiki) and Andrey Proshutinsky (WHOI) (Type XCTD-3 made by Sippican). The probes fell freely in the water measuring temperature and conductivity every 0.15 m from the surface down to 1100 m. Data were transmitted to the ship during the freefall by a thin conducting wire extending from the XCTD to an onboard computer. In open water, the ship slowed to 12 knots for the deployments. In ice the ship stopped completely to prevent sea ice from cutting the thin transmission wire. The XCTD probe took 5 minutes to descend from the surface to 1100 m.

During the ship's transit north, 31 probes were deployed at 30 sites on Baffin Bay. A total of 53 probes were deployed as part of the Canada Basin program. Locations are listed in **Appendix 2**. Accuracy of the XCTDs are ± 0.02 degrees in temperature, ± 0.03 mS/cm in conductivity (approximately ± 0.04 psu in salinity) and ± 5 to 20 m in depth. The salinity accuracy of XCTDs was improved to ± 0.01 psu by calibration with the CTD data, matching the XCTD data with the CTD data from deep water.

For more information and data see the JAMSTEC website: http://www.jamstec.go.jp/e/.

2.5.3 Moorings and Buoys

Six mooring operations and two buoy deployments were performed by Richard Krishfield, John Kemp and Kris Newhall (WHOI) during the cruise. All mooring and buoy operations were performed in the presence of ice. For details on mooring and buoy locations see Table 12 below.

The three deep WHOI moorings (Proshutinsky) deployed in August 2004 collected temperature, salinity, pressure, and current using a McLane Moored Profiler (MMP) that traveled between depths of 50 m and 2050 m, plus ice draft information from an Ice Profiling Sonar, bottom pressure data, and one mooring (A) included a sediment trap for collecting vertical particle flux samples. These moorings were recovered, serviced and redeployed during the 2005-04 cruise. A fourth deep MMP mooring was also deployed. The methods are described in Kemp et al. (2005) and for more information see the web page: http://www.whoi.edu/beaufortgyre.

Two pairs of buoys, an Ice Tethered Profiler (ITP; Toole et al., 2006) and an Ice Mass Balance Buoy (IMBB; Perovich - Cold Regions Research and Engineering Laboratory), were deployed in the northwest and northeast of the study area. The ITP is a profiling CTD, set up to profile between depths of 7 and 800 m. The IMBB measures ice thickness and temperature, and surface air temperature, pressure and snow accumulation. Both buoys relay data daily to shore via satellite. For more information, please see the ITP web page: http://www.whoi.edu/itp/ and the technical description by Krishfield et al. (2006).

The Canadian Basin Observing System (CABOS) IARC mooring (Polyakov), also deployed in 2004 in 1100 m of water in the southeast corner of the Canada Basin, collected temperature, salinity, pressure, and current using a MMP that traveled between depths of 50 m and 1050 m. After recovery, a new profiler was installed and the mooring redeployed close to the same location. For more information see the web page http://nabos.iarc.uaf.edu/.

In addition to the above moorings deployed under the JOIS program, a shallow mooring was placed on the Beaufort shelf-break at BS-3 in 150 m of water for Dr. R. Pickart at WHOI. The mooring, to measure the shallow boundary current of Pacific water, had a Coastal Moored Profiler (CMP) CTD (without current meter), Arctic Winch with CTD above the top float, Upward Looking Sonar for ice draft, and bottom pressure recorder.

Reference

Toole, J., Krishfield, R., Proshutinsky, A., Ashjian, C., Doherty, K., Frye, D., Hammar, T., Kemp, J., Peters, D., Timmermans, M.-L., von der Heydt, K., Packard, G. and Shanahan, T. 2006. Ice Tethered-Profilers Sample the Upper Arctic Ocean. *EOS, Transactions of the American Geophysical Union*. 87(41):434-438.

Table 12. Mooring and Buoy Locations.

Mooring Designation	Investigator	Water Depth (m)	Recovery Time	Recovery Location	Deployment Time	Deployment Location
CABOS	IARC Polyakov	1112	4-Aug-05 14:46 UTC	71° 46.506'N 131° 52.711'W	30-Aug-05 21:12 UTC	71° 49.676'N 131° 45.663'W
BS-3	WHOI Pickart	149	NA	NA	6-Aug-05 22:12 UTC	71° 23.732'N 152° 02.175'W
BGOS-A	WHOI Proshutinsky	3825	9-Aug-05 18:40 UTC	75° 00.251' N 149° 58.108'W	12-Aug-05 20:05 UTC	75° 00.304' N 149° 53.413'W
BGOS-B	WHOI Proshutinsky	3821	14-Aug-05 15:08 UTC	78° 01.084'N 149° 52.459'W	17-Aug-05 19:25 UTC	77° 59.585'N 149° 57.866'W
BGOS-C	WHOI Proshutinsky	3722	26-Aug-05 00:01 UTC	76° 59.452'N 139° 58.307'W	26-Aug-05 20:50 UTC	76° 58.251'N 139° 59.539'W
BGOS-D	WHOI Proshutinsky	3510	NA	NA	28-Aug-05 21:10 UTC	74° 00.146'N 139° 58.985'W
Buoys: ITP1; IMB 07949	WHOI Toole/Perovich	3830	NA	NA	15-Aug-05 22:00 UTC	78° 51.1'N 150° 15.9'W
Buoys: ITP3; IMB 07950	WHOI Toole/Perovich		NA	NA	23-Aug-05 18:00 UTC	77° 36.1'N 142° 11.8'W

2.5.4 *Vertical Net Tows*

Zooplankton sampling was conducted on board by Hugh Maclean with help from the CTD watch using a modified Bongo net system consisting of four nets. One bongo frame was fitted with a 150 µm mesh net and a 236 µm mesh net. A second frame was fitted with two 53 µm mesh nets and was attached perpendicular to the first bongo frame. Each net contained a unidirectional flowmeter to measure the amount of water flowing through the nets. The vertical net tows were 100 m deep, with two tows per station. The station locations of all zooplankton casts are reported in **Appendix 2**.

Samples from the first tow were preserved in formalin, individually from the 150 and 236 µm mesh nets, whereas the samples from the 53 µm nets were combined into one sample. From the second tow, the 236 µm net sample and the combined 53 µm net sample were preserved in 100% ethanol, and the 150 µm net sample was washed with 4% ammonium formate and dried at 50 °C for 24 hours (Table 13). The formalin samples will be examined for species identification and the ethanol samples for DNA sequence analysis. These samples have not been analyzed to date (March 2010). The dried sample provided a measurement of biomass (weighed by John Harris at IOS). Samples used for the determination of biomass were stored in a dessicator for 5 days before being weighed by John Harris. The samples from the 236 µm mesh were collected for John Nelson and samples from the 150 µm and 53 µm mesh for Russ Hopcroft (UAF). The 53 µm ethanol sample was collected for the Census of Marine Life's DNA barcoding study, an affiliated program of the International Council of Science, Scientific Committee on Oceanic Research.

Table 13. Zooplankton biomass weights.

Station	Latiitude (°N)	Longitude (°W)	Sample No.	Biomass (g)
CB1	71.78	131.87	A	1.00564
*CB4	74.98	149.93	B	0.45819
CB4	74.98	149.93	C	0.67431
CB9	78.00	149.84	D	0.73696
CB15	76.98	140.00	E	0.77125
			std 0.005	*0.00502*

*This sample was contaminated.

3. REFERENCES

Arar, E.J. and Collins, B.B. 1997. In vitro Determination of Chlorophyll a and Pheophytin in Marine and Freshwater Algae by Fluorescence. Revision 1.2 September 1997, US.EPA Method 445.0.

Barwell-Clarke, J. and Whitney, F. 1996. Institute of Ocean Sciences Nutrient Methods and Analysis. *Can. Technical Rep. Hydrogr. Ocean Sci.* 182:vi + 43 p.

Carpenter, J.H. 1965. The Chesapeake Bay Institute technique for the Winkler dissolved oxygen method. *Limnol. Oceanogr.* 10:141-3.

Dickson, A. 2001. Reference materials for oceanic measurements. *Oceanography*. 14(4):21-22.

Dickson, A.G., Afghan, J.D. and Anderson, G.C. 2003. Reference for oceanic CO_2 analysis: a method for the certification of total alkalinity. *Mar. Chem.* 80(2-3):185-197.

DOE. 1994. *In*: Dickson, A.G. and Goyet, C. (Eds.). Handbook of Methods for the Analysis of the Various Parameters of the Carbon Dioxide System in Sea Water, Version 2. ORNL/CDIAC-74.

Edmonds, H.N., Smith, J.N., Kilius, L.R., Livingston, H.D. and Edmond, J.M. 1998. ^{129}I in archived seawater samples: Source functions and tracer comparisons. *Deep-Sea Research I.* 45(6):1111-1125.

Falkner, K.K., MacDonald, R.W., Carmack, E.C. and Weingartner, T. 1994. The potential of barium as a tracer of Arctic water masses. p. 63-76. *In:* O.M. Johannessen, R.D. Muench and J.E. Overland [eds.]. The Polar Oceans and Their Role in Shaping the Global Environment: The Nansen Centennial Volume, AGU Geophys. Monograph Series, AGU Books, Washington, DC.

JGOFS. 1994. Protocols for the Joint Global Ocean Flux Study (JGOFS) core measurements, Manual and guides 29, Scientific Committee on Ocean Research, United Nations Educational, Scientific and Cultural Organization, Paris, 170 pp.

Johnson, K.M., Wills, K.D., Butler, D.B., Johnson, W.K. and Wong, C.S. 1993. Coulometric total carbon dioxide analysis for marine studies: maximizing the performance of an automated gas extraction system and coulometric detector. *Mar. Chem.* 44:167-187.

Kemp, J., Newhall, K., Ostrom, W., Krishfield, R., and Proshutinsky, A. 2005. The Beaufort Gyre Observing System 2004: Mooring Recovery and Deployment Operations in Pack Ice; WHOI Technical Report WHOI-2005-5.

Krishfield, R., Doherty, K., Frye, D., Hammar, T., Kemp, J., Peters, D., Proshutinsky, A., Toole, J. and von der Heydt, K. 2006. Design and Operation of Automated Ice-Tethered Profilers for Real-time Seawater Observations in the Polar Oceans. WHOI-2006-11: 79 p.

Lewis, E.L. and Perkin, R.G. 1981. The Practical Salinity Scale 1978: conversion of existing data. *Deep Sea Res.* 28 A:307-328.

Li, W.K.W. and Dickie, P.M. 2001. Monitoring phytoplankton, bacterioplankton, and virioplankton in a coastal inlet (Bedford Basin) by flow cytometry. *Cytometry*. 44:236-246.

Marie, D.M., Partensky, F., Vaulot, D., and Brussaard, C. 1999. Enumeration of phytoplankton, bacteria, and viruses in marine samples. Current Protocols in Cytometry. 11.11.1-11.11.15. Wiley & Sons, New York.

Minkley, B. and Chase, G. 1997. Dissolved Oxygen Determination Methods and Procedures. Institute of Ocean Sciences, July 30, 1997. Internal Document.

Seabird. 2008. Calculation of Calibration Coefficients for Sea Tech, Chelsea (Alphatracka) and WET Lab Cstar Transmissometers. Application Note No. 7.

Smith, J.N., Ellis, K.M. and Jones, E.P. 1990. Cesium-137 transport into the Arctic Ocean through Fram Strait. *Journal of Geophysical Research.* 95(C2):1693-1701.

Smith, J.N. and Ellis, K.M. 1995. Radionuclide tracer profiles at the CESAR Ice Station and Canadian Ice Island in the Western Arctic Ocean. *Deep-Sea Research II.* 42(6):1447-1470.

Smith, J.N., Ellis, K.M. and Kilius, L.R. 1998. ^{129}I and ^{137}Cs tracer measurements in the Arctic Ocean. *Deep-Sea Research I.* 45(6):959-984.

Smith, J.N., Ellis, K.M. and Boyd, T.M. 1999. Circulation features in the Central Arctic Ocean revealed by nuclear fuel reprocessing tracers from SCICEX 95 and 96, 1999. *Journal of Geophysical Research.* 104(C12):29,663-29,677.

Smith, J.N., Jones, E.P., Moran, S.B., Smethie Jr., W.M. and Kieser, W.E. 2005. ^{129}I/CFC-11 Transit times for Denmark Strait Overflow Water in the Labrador and Irminger Seas. *Journal of Geophysical Research*. 110, C05006, doi:10.1029/2004JC002516.

Strickland, J.D.H. and Parsons, T.R. 1972. A practical handbook of seawater analysis. Fisheries Research Board of Canada.

Taylor, J.R. 1997. An Introduction to Error Analysis: Second Edition. University Science Books, CA, 327 pp.

Toole, J., Krishfield, R., Proshutinsky, A., Ashjian, C., Doherty, K., Frye, D., Hammar, T., Kemp, J., Peters, D., Timmermans, M.-L., von der Heydt, K., Packard, G. and Shanahan, T. 2006. Ice Tethered-Profilers Sample the Upper Arctic Ocean. *EOS, Transactions of the American Geophysical Union*. 87(41):434-438.

4. RELATED DATA REPORTS IN THE CANADIAN DATA REPORT OF HYDROGRAPHY AND OCEAN SCIENCES SERIES

Birch, J.R., Lemon, D.D., Fissel, D.B., Melling, H. 1987. Arctic data compilation and appraisal. Volume 12, Beaufort Sea and Amundsen Gulf : physical oceanography : temperature, salinity, currents, water levels and waves : revised and updated to include 1914 through 1986. *Can. Data Rep. Hydrogr. Ocean Sci.* 5(12): 469 p.

Carmack, E., Papadakis, J.E., Macdonald, D.M., and Macdonald, R.W. 1989. NOGAP B.6. Volume 6, Physical data collected in the Beaufort Sea, summer, 1987. *Can. Data Rep. Hydrogr. Ocean Sci.* 60(6): 219 p.

Carmack, E.C., Macdonald, R.W., O'Brien, M., Pearson, R., Timmermans, L., Sieberg, D., Von Hardenberg, B., Sutherland, N., Tuele, D., Jackson, F., and L. White, L. 1996. Physical and chemical data collected in the Beaufort Sea and the Canadian archipelago, August-September 1995. *Can. Data Rep. Hydrogr. Ocean Sci.* 147: 281 p.

Cornford, A.B., Lemon, D.D., Fissel, D.B., Melling, H., Smiley, B.D., Herlinveaux, R.H., and Macdonald, R.W. 1982. Arctic data compilation and appraisal. Volume 1, Beaufort Sea: physical oceanography : temperature, salinity, currents and water levels. *Can. Data Rep. Hydrogr. Ocean Sci.* 5(1): 279 p.

Cuypers, L.E., Blaskovich, A.W., Carmack, E.C., and R.W. Macdonald, R.W. 1988. NOGAP B.6: physical data collected in the Beaufort Sea, September 1986. *Can. Data Rep. Hydrogr. Ocean Sci.* 59: 149 p.

Macdonald, D.M., Cuypers, L.E., McCullough, D., Carmack, E., and Macdonald, R.W. 1988. NOGAP B.6. Volume 2, Physical data collected in the Beaufort Sea, March-June 1987. *Can. Data Rep. Hydrogr. Ocean Sci.* 60(2): 157 p.

Macdonald, R.W., Iseki, K., Carmack, E.C., Macdonald, D.M., O'Brien, M.C., and McLaughlin, F.A. 1988. Data report: NOGAP B.6 : Beaufort Sea oceanography, September, 1986. *Can. Data Rep. Hydrogr. Ocean Sci.* 58: 68 p.

Macdonald, R.W., Iseki, K., O'Brien, M.C., McLaughlin, F.A., McCullough, D., Macdonald, D.M., Carmack, E.C., Adams, H., Yunker, M., Miskulin, G., and Buckingham, S. 1988. NOGAP B.6. Volume 4, Chemical data collected in the Beaufort Sea, Summer, 1987. *Can. Data Rep. Hydrogr. Ocean Sci.* 60(4): 103 p.

Macdonald, R.W., Iseki, K., O'Brien, M.C., McLaughlin, F.A., McCullough, D., Macdonald, D.M., Carmack, E.C., Yunker, M., Buckingham, S. and Miskulin, G. 1988. NOGAP B.6. Volume 5, Chemical data collected in the Beaufort Sea and Mackenzie River delta, March-July 1987. *Can. Data Rep. Hydrogr. Ocean Sci.* 60(5): 55 p.

Macdonald, R.W., Carmack, E.C., O'Brien, M.C., McLaughlin, F.A., Minkley, B.G., and Berger-North, K. 1990. Oceanographic data collected from the Sir John Franklin in the Beaufort Sea, September 1989. *Can. Data Rep. Hydrogr. Ocean Sci.* 80: 100 p.

Macdonald, R.W., Carmack, E.C., McLaughlin, F.A., Sieberg, D., O'Brian, M.C., Paton, D., Pearson, R., Liangfeng, Y., and Gobeil, C. 1991. Oceanographic data collected from the HENRY LARSEN in the Beaufort Sea, August-September 1990. *Can. Data Rep. Hydrogr. Ocean Sci.* 97: 142 p.

Macdonald, R.W., Pearson, R., Sieberg, D., McLaughlin, F.A., O'Brien, M.C. Paton, D.W., Carmack, E.C., Forbes, J.R., and Barwell-Clarke, J. 1992. NOGAP B.6, Physical and chemical data collected in the Beaufort Sea and Mackenzie River delta, April-May 1991. *Can. Data Rep. Hydrogr. Ocean Sci.* 104: 154 p.

Macdonald, R.W., Sieberg, D., Pearson, R., Paton, M., O'Brien, M.C., McLaughlin, F.A., and Carmack, E.C. 1992. Oceanographic data collected from the Henry Larsen in the Beaufort Sea, September 1991. *Can. Data Rep. Hydrogr. Ocean Sci.* 112: 108 p.

Macdonald, R.W., O'Brien, M., Carmack, E.C., Pearson, R., McLaughlin, F.A., Sieberg, D., Barwell-Clarke, J., Paton, D.W., and Tuele, D. 1995. Physical and chemical data collected in the Beaufort, Chukchi and east Siberian seas, August-September 1993. *Can. Data Rep. Hydrogr. Ocean Sci.* 139: 287 p.

McLaughlin, F., Carmack, E., O'Brien, M., Adamson, L., Barwell-Clarke, J., Gatien, G., Hingston, M., Johnston, P., May, B., Melling, H., Poliquin, M., Riedel, D., Sieberg, D., Tuele, D., VanHardenberg, B., Walsh, D., Welch, B., and Welch, C. 2008. Physical and chemical data from the Canadian Arctic Archipelago, August 28 to September 18, 1997. *Can. Data Rep. Hydrogr. Ocean. Sci.* 176: vi + 140 p.

McLaughlin, F., Carmack, E.C., Zimmermann. S., Sieberg, D., White, L., Barwell-Clarke, J., Steel, M., and Li, W.K.W. 2008. Physical and chemical data from the Canada Basin, August 2004. *Can. Data Rep. Hydrogr. Ocean. Sci.* 140: vi + 185 p.

McLaughlin, F., Carmack, E., O'Brien, M., Arfeuille, G., Barwell-Clarke, J., Sutherland, N., Tuele, D., Gatien, G., Melling, H., Zimmermann, S. and Corkum, M. 2009. Physical and Chemical Data from the Canadian Arctic Archipelago, August 23 to September 8, 1999. *Can. Data Rep. Hydrogr. Ocean Sci.* 179: vii + 140 p.

McLaughlin, F., Carmack, E., O'Brien, M., Bacle, J., Gatien, G., Tuele, D., White, L., Moody, G., Balsom, A. and Corkum, M. 2009. Physical and Chemical Data from the Beaufort Sea and Western Canadian Arctic Archipelago, September 2 to 16, 2000. *Can. Data Rep. Hydrogr. Ocean Sci.* 180: viii + 167 p.

McLaughlin, F., Proshutinsky, A., Carmack, E.C., Shimada, K., Corkum, M., Forsland, V., Guay, C., Guéguen, C., van Hardenberg, B., Hopcroft, R., Itoh, M., Krishfield, R., Miller, L., Nelson, J., Proshutinsky, A., Richardson, W., Sieberg, D., Smith, J., Steel, M., Tanaka, N., White, L. and Zimmermann, S. 2010. Physical, chemical and zooplankton data from the Canada Basin, August 2003. *Can. Data Rep. Hydrogr. Ocean. Sci.* 184: ix + 303 p.

Paton, D.W., Abehennah, A., Grieve, W., and Macdonald, R.W. 1994. NOGAP B.6, oxygen isotope data from water and ice cores from the Beaufort Sea, September 1990 and May 1991. *Can. Data Rep. Hydrogr. Ocean Sci.* 134: 118 p.

Paton, D.W., Knight, V., and Macdonald, R.W. 1997. NOGAP B.6 oxygen isotope data from water and ice cores from the Beaufort Sea, May 1992. *Can. Data Rep. Hydrogr. Ocean Sci.* 149: 23 p.

Pearson, R., O'Brien, M., Sieberg, D., McLaughlin, F.A., Paton, D.W., Tuele, D., Barwell-Clarke, J., Carmack, E.C., Macdonald, R.W., and Galbraith, M. 1994. NOGAP B.6, Physical and chemical data collected in the Beaufort Sea and Mackenzie River delta, April-May and September, 1992, and ice core data collected in 1991-1992. *Can. Data Rep. Hydrogr. Ocean Sci.* 129: 199 p.

Thomas, D.J., Macdonald, R.W., and Cornford, A.B. 1982. Arctic data compilation and appraisal. Volume 2, Beaufort Sea: chemical oceanography. *Can. Data Rep. Hydrogr. Ocean Sci.* 5(2): 243 p.

Thomas, D.J., Noone, F., Blyth, A., and Smiley, B.D. 1990. Arctic data compilation and appraisal. Volume 20 (Part 2), Beaufort Sea: chemical oceanography: hydrocarbons, metals, pigments, nutrients, oxygen and others : revised and updated to include 1950 through 1987. *Can. Data Rep. Hydrogr. Ocean Sci.* 5(20): Pt 1&2 2 v.

Woods, S.M., and Smiley,, B.D. 1987. Arctic data compilation and appraisal. Volume 9, Beaufortt Sea: biological oceanography: bacteria, plankton, epontic community,, 1914 to 1985. *Can. Data Rep. Hydrogr. Ocean Sci.* 5(9): 394 p.

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1. SCIENCE PARTICIPANTS

Table 1. Onboard Science Team

Name	Affiliation	Position
Sarah Zimmermann	DFO-IOS	Chief Scientist
Doug Sieberg	DFO-IOS	Chief Technician
Hugh Maclean	DFO-IOS	CTD watch leader
Jane Eert	DFO-IOS	CTD watchstander/Data manager
Mary Steel	DFO-IOS	Oxygen Analysis
Linda White	DFO-IOS	Nutrient Analysis
Nes Sutherland	DFO-IOS	CFC Analysis
Wendy Richardson	DFO-IOS	CFC Analysis
Michiyo Kawai	DFO-IOS	Alkalinity Analysis
Jeffrey Carpenter	DFO-IOS	CTD Watchstander/Chlorophyll Analysis
Ryan North	DFO-IOS	CTD Watchstander/Ammonium Analysis
William Burt	DFO-IOS	CTD Watchstander/Bacteria Collection
Masuo Hosono	JAMSTEC	CTD Watchstander/ XCTD Technician
Waldemar Walczowski	IOP	CTD Watchstander/ LADCP
Richard Krishfield	WHOI	WHOI Mooring Operations
John Kemp	WHOI	WHOI Mooring Operations
Kris Newhall	WHOI	WHOI Mooring Operations
Chris Linder	WHOI	Outreach

Table 2. Principal Investigators

Name	Affiliation	Program
Fiona McLaughlin	DFO -IOS	Program Lead CTD and chemistry
Eddy Carmack	DFO-IOS	CTD
Andrey Proshutinsky	WHOI	WHOI moorings
Koji Shimada	JAMSTEC	XCTD
Chris Guay	OSU	Barium
John Smith	DFO-BIO	^{129}I, ^{137}Cs
C.S. Wong	IOS	^{13}C
Bill Li	BIO	Bacteria
Céline Guéguen	UBC/IOS	CDOM
Russ Hopcroft	UAF	Zooplankton
John Nelson	UVic/DFO	Zooplankton
Waldemar Walczowski	IOP	LADCP
Igor Polyakov	IARC	CABOS mooring
Robert Pickart	WHOI	BS-3 Mooring
John Toole	WHOI	Ice Buoys (ITP)
Don Perovich	CRREL	Ice Buoys (IMBB)

Table 3. Affiliation Abbreviation

BIO	Bedford Institute of Oceanography, NS
DFO	Department of Fisheries and Oceans, Canada
IARC	International Arctic Research Center, Alaska
IOP	Institute of Oceanology Polish Academy of Sciences, Poland
IOS	Institute of Ocean Sciences, BC
JAMSTEC	Japan Agency for Marine-Earth Science Technology, Japan
OSU	Oregon State University
UAF	University of Alaska Fairbanks, Alaska
UBC	University of British Columbia, BC
UVic	University of Victoria, BC
WHOI	Woods Hole Oceanographic Institution, Massachusetts

2. LOCATION OF SCIENCE STATIONS

Locations of CTD/Rosette, XCTD, zooplankton vertical net and over-the-side bucket casts, as well as the mooring and buoy recovery and deployments are listed in the tables below.

Table 4. CTD/Rosette Casts

Cast	Station	Latitude (N)	Longitude (E)	Date (UTC)	Time (UTC)	Water Depth (m)	Max CTD Depth (m)	Sample Numbers	Comment
1	1	74.2647	-95.3890	29-Jul-05	16:19	205	200	1-8	Northwest Passage
2	2	68.8733	-101.4435	31-Jul-05	14:14	46	40	9-13	Northwest Passage
3	3	68.7062	-102.7630	31-Jul-05	18:06	105	100	14-18	Northwest Passage
4	4	68.7000	-103.7700	31-Jul-05	21:04	105	100	19-24	Northwest Passage
5	AG5	70.5515	-122.9032	3-Aug-05	12:41	641	638	25-45	Northwest Passage
6	CB-1/ CABOS	71.7688	-131.8172	4-Aug-05	05:47	1098	1093	46-68	
7	CB-1/ CABOS	71.7710	-131.8670	4-Aug-05	10:31	1118	250	69-73	Second cast for bottle flushing test
8	CB-1/ CABOS	71.7657	-131.8603	4-Aug-05	11:25	1120	1000	74-91	Second cast for bottle flushing test
9	CB-28a	70.5850	-139.9967	5-Aug-05	15:04	866	871	92-112	
10	CB-28b	71.0000	-139.9997	5-Aug-05	17:33	2079	2073	113-136	
11	BS-3a	71.3650	-151.9708	6-Aug-05	20:21	97	90	na	CTD only, no bottles
12	BS-3	71.3977	-151.9948	7-Aug-05	01:37	150	151	137-146	
13	BS-3b	71.5802	-151.5175	7-Aug-05	04:52	>1500	1000	147-166	Second cast for Cesium/Iodine samples
14	BS-3b	71.6237	-151.4912	7-Aug-05	10:58	>1500	1513	167-187	
15	BS-3c	71.7958	-150.8415	7-Aug-05	14:44	2462	2456	188-210	
16	BS-3d	72.0035	-150.0002	7-Aug-05	19:18	3115	3108	211-234	
17	CB-2	73.0020	-149.9920	8-Aug-05	08:25	~3670	3564	235-258	
18	CB-3	74.0035	-149.9597	8-Aug-05	21:13	3830	1000	259-278	Second cast for Cesium/Iodine samples
19	CB-3	74.1898	-149.7422	9-Aug-05	03:42	3818	3812	279-302	
20	CB-4	74.9793	-149.9347	10-Aug-05	00:43	3830	3820	303-326	
21	CB-5	75.2777	-153.2465	10-Aug-05	10:13	3843	3838	327-337	
22	CB-5a	75.5718	-155.5615	10-Aug-05	17:46	3846	3836	338-361	
23	CB-5b	75.6188	-156.1637	10-Aug-05	23:20	2130	2094	na	CTD only, no bottles
24	CB-6	74.7533	-147.7518	11-Aug-05	19:39	3802	3796	362-385	
25	CB-4	74.9882	-149.8727	12-Aug-05	21:55	3840	850	386-409	Second cast for thermohaline intrusion study
26	CB-7	75.9878	-149.9657	13-Aug-05	08:07	3829	3821	410-433	
27	CB-8	76.9888	-150.0138	13-Aug-05	19:22	3830	3800	434-457	
28	CB-9	78.0018	-149.8377	14-Aug-05	07:33	3824	3816	458-481	

Cast	Station	Latitude (N)	Longitude (E)	Date (UTC)	Time (UTC)	Water Depth (m)	Max CTD Depth (m)	Sample Numbers	Comment
29	CB-11	78.9722	-149.9947	15-Aug-05	03:31	3831	800	481-492	Second cast for Cesium/Iodine samples
30	CB-11	78.9750	-149.9952	15-Aug-05	04:48	3831	3812	493-516	
31	Ice_floe	78.8655	-150.4713	15-Aug-05	10:10	3830	3810	na	Cast at Ice Buoy deployment; CTD only, no bottles
32	CB-10	78.2875	-153.2477	16-Aug-05	08:52	2450	800	517-528	Second cast for Cesium/Iodine samples
33	CB-10	78.2852	-153.2527	16-Aug-05	10:19	2504	2436	529-552	
34	CB-10a	78.2615	-153.9487	16-Aug-05	16:09	946	937	na	CTD only, no bottles
35	CB-10b	78.1778	-152.8525	16-Aug-05	19:21	3123	3095	na	CTD only, no bottles
36	CB-9	77.9822	-150.0460	17-Aug-05	10:23	~3800	1580	553-572	Second cast thermohaline intrusion study
37	CB-12	77.7020	-146.7030	18-Aug-05	01:59	3814	3802	573-596	
38	CB-13	77.2982	-143.3703	18-Aug-05	13:19	3782	3776	597-620	
39	CB-15	76.9850	-139.9865	26-Aug-05	07:04	3725	3719	628-651	
40	CB-15	76.9810	-139.9955	26-Aug-05	12:54	3725	800	652-671	Second cast for Cesium/Iodine samples
41	CB-15	76.9652	-139.9618	26-Aug-05	21:59	3732	600	672-691	Second cast for thermohaline intrusion study
42	CB-17	75.9977	-139.7845	27-Aug-05	11:18	~3700	1004	692-715	Shortened cast to save time
43	CB-18	75.0633	-140.3732	27-Aug-05	21:59	3660	3644	716-739	
44	CB-21	74.0343	-140.0165	28-Aug-05	11:05	3520	3514	740-763	
45	CB-27	73.0067	-139.9983	29-Aug-05	05:15	3234	2000	764-787	Shortened cast to save time
46	CB-29	71.9972	-139.9877	29-Aug-05	15:08	2680	2673	788-811	
47	CB-23a	72.7005	-135.9668	30-Aug-05	03:39	2630	2624	812-835	
48	CB-31a	72.1098	-133.2298	30-Aug-05	13:39	1767	1761	836-859	
49	CB-1/ CABOS	71.7558	-131.7378	30-Aug-05	18:10	1061	1055	860-883	
50	CB-1a	71.3938	-130.9020	31-Aug-05	00:11	248	243	884-895	

Table 5. XCTD Cast Locations in Baffin Bay

XCTD Cast	Latitude (N)	Longitude (W)	Date (UTC)	Time (UTC)	Water Depth (m) [Depth with * is from chart]	Max XCTD Depth (m)	Probe S/N	File name
1	64.0038	54.9979	24-Jul-05	04:05	1280		05022376	0507240401
2	64.3406	55.5441	24-Jul-05	06:08	1140	bottom	05022377	0507240605
3	64.6695	56.0708	24-Jul-05	08:00	780	bottom	05022378	0507240755
4	64.9984	56.6014	24-Jul-05	09:45	650	bottom	05022379	0507240942
5	65.3352	57.1384	24-Jul-05	11:30	600	bottom	05022380	0507241126
6	65.6689	57.6720	24-Jul-05	13:20	580	bottom	05022381	0507241314
7	66.0027	58.1984	24-Jul-05	15:43	555	bottom	05022382	0507241538
**7	66.0256	58.2360	24-Jul-05	15:50	566	bottom	05022383	0507241548
8	66.3372	58.7322	24-Jul-05	17:31	626	bottom	05022384	0507241725
9	66.6680	59.2732	24-Jul-05	19:25	907	bottom	05022385	0507241919
10	67.0076	59.7911	24-Jul-05	21:53	990	bottom	05022386	0507242152
11	67.3358	60.3316	25-Jul-05	00:05	1000 *		05022387	0507250003
12	67.6675	60.3710	25-Jul-05	01:47	1767 *		05022388	0507250141
13	68.3335	60.3498	25-Jul-05	06:39	1540 *		05022389	0507250639
14	69.0024	60.7204	25-Jul-05	10:27	1700 *		05022390	0507251020
15	69.6684	60.8636	25-Jul-05	13:40	1880 *		05022391	0507251330
16	70.3499	61.1993	25-Jul-05	17:03	1118 *		05022392	0507251658
17	71.0109	61.8643	25-Jul-05	20:01	1920 *		05022393	0507251955
18	71.6818	62.0694	25-Jul-05	22:56	2260 *		05022394	0507252251
19	72.3289	62.5271	26-Jul-05	01:53	625 *		05022395	0507260149
20	72.9966	61.8441	26-Jul-05	04:55	1120 *	bottom	05022396	0507260542
21	74.7168	68.4999	26-Jul-05	19:27	1525 *		05022397	0507261926
22	74.6158	69.9836	26-Jul-05	21:50	1000 *		05022399	0507272146
23	73.8176	70.9999	27-Jul-05	01:29	1250 *	bottom	05022398	0507270122
24	73.8007	71.9969	27-Jul-05	03:00	1095 *	wire cut 1035	05032436	0507270300
25	73.8363	73.0689	27-Jul-05	04:42	865 *	bottom	05032437	0507270436
26	73.9022	73.9971	27-Jul-05	06:05	833 *	bottom	05032438	0507270558
27	74.0040	75.0726	27-Jul-05	07:22	806 *	bottom	05032439	0507270715
28	74.0849	80.0133	27-Jul-05	13:15	803 *	wire cut 607	05032440	0507271303
29	74.2015	84.9995	27-Jul-05	19:15	534 *	bottom	05032441	0507271913
30	74.3331	90.0055	28-Jul-05	00:57	284	bottom	05032442	0507280051

**** Second cast; both casts good.**

Table 6. XCTD Cast Locations in Canada Basin

XCTD Cast	Latitude (N)	Longitude (W)	Date (UTC)	TIME (UTC)	Water Depth (m) Depth with * is from chart	Max XCTD Depth (m)	Probe Type (XCTD-1 or XCTD-3)	File name
1	71.7005	132.5667	4-Aug-05	17:33	1200	1100	3	0508041724
2	71.1846	134.9633	5-Aug-05	03:08	750	bottom	1	0508050305
3	70.9430	137.3866	5-Aug-05	08:38	1450	1100	1	0508050838
4	70.9996	141.4992	5-Aug-05	21:06	2526*	1100	1	0508052101
5	71.0002	142.9968	5-Aug-05	23:31	1400*	1100	1	0508052325
6	70.9983	144.4999	6-Aug-05	01:47	600*	bottom	1	0508060146
7	70.9983	146.0329	6-Aug-05	04:19	1400*	1100	3	0508060414
8	71.1109	147.4928	6-Aug-05	06:56	1050	1100	3	0508060653
9	72.4806	149.8959	8-Aug-05	02:39	3600*	1100	3	0508080238
10	73.4987	150.0078	8-Aug-05	14:40	3800*	1100	3	0508081438
11	74.4993	150.0020	9-Aug-05	08:50	3800*	1100	3	0508090849
12	75.1452	151.5512	10-Aug-05	06:47	3800*	wire cut 1020	3	0508100647
13	75.4499	154.4839	11-Aug-05	04:31	3800*	1100	3	0508110428
14	74.8810	148.9973	12-Aug-05	09:13	3800*	1100	3	0508120913
15	75.4892	149.8986	13-Aug-05	03:04	3800*	1100	3	0508130255
16	76.3315	149.9918	13-Aug-05	13:29	3800*	1100	3	0508131330
17	76.6627	149.9740	13-Aug-05	16:23	3800*	1100	3	0508131624
18	77.3285	150.0328	14-Aug-05	00:40	3800*	1100	3	0508140038
19	77.6408	150.0573	14-Aug-05	03:42	3800*	1100	3	0508140341
20	78.3237	150.0135	14-Aug-05	21:36	3800*	1100	3	0508141234
21	78.6488	150.1135	15-Aug-05	00:58	3800*	1100	3	0508150055
22	78.7108	151.1083	16-Aug-05	02:17	3500*	1100	3	0508160214
23	78.5699	151.7807	16-Aug-05	04:48	3835	1100	3	0508160444
24	78.4211	152.6110	16-Aug-05	06:58	3840	1100	3	0508160658
25	77.9842	151.4705	17-Aug-05	00:31	3840	1100	3	0508170024
26	77.8563	148.3788	17-Aug-05	22:30	3800*	1100	3	0508172230
27	77.4613	145.0493	18-Aug-05	09:13	3800*	1100	3	0508180913
28	77.5228	142.1789	18-Aug-05	20:20	3700*	1100	3	0508182019
29	77.9735	141.5782	19-Aug-05	20:59	3700*	1100	3	0508192102
30	77.2933	140.6195	25-Aug-05	15:40	3700*	1100	1	0508251537
31	76.6651	140.0708	27-Aug-05	03:19	3500*	1100	1	0508270317
32	76.3713	139.8372	27-Aug-05	06:50	3500*	1100	1	0508270647
33	75.6632	140.4230	27-Aug-05	16:12	3500*	wire cut 1043	1	0508271610
34	75.3342	141.0020	27-Aug-05	19:04	3500*	1100	1	0508271901
35	74.6724	140.4287	28-Aug-05	05:04	3600*	1100	1	0508280503
36	74.3403	140.3605	28-Aug-05	07:57	3500*	1100	1	0508280756
37	73.6656	140.0901	28-Aug-05	23:53	3400*	1100	1	0508282351
38	73.3151	140.1932	29-Aug-05	02:30	3300*	wire cut 755	1	0508290230
39	73.3140	140.1941	29-Aug-05	02:37	3300*	1100	1	0508290237
40	72.6638	140.3997	29-Aug-05	09:30	2900*	1100	1	0508290927
41	72.3337	140.1768	29-Aug-05	11:51	2700*	1100	1	0508291150

XCTD Cast	Latitude (N)	Longitude (W)	Date (UTC)	TIME (UTC)	Water Depth (m) Depth with * is from chart	Max XCTD Depth (m)	Probe Type (XCTD-1 or XCTD-3)	File name
42	72.3084	138.6368	29-Aug-05	20:14	2700*	1100	3	0508292012
43	72.4264	137.1248	29-Aug-05	23:15	2500*	1100	3	0508292314
44	72.3647	135.1958	30-Aug-05	09:01	2250*	1100	3	0508300901
45	72.1955	134.2690	30-Aug-05	11:19	2000*	1100	3	0508301118
46	71.9327	132.5862	30-Aug-05	16:12	1200*	1100	3	0508301611
47	71.5878	131.3183	30-Aug-05	22:33	727	bottom	3	0508302235
48	71.5027	130.9598	30-Aug-05	23:33	441	bottom	3	0508302332
49	71.3471	130.7453	31-Aug-05	01:07	152	bottom	3	0508310106
50	70.9200	126.0093	31-Aug-05	06:58	389	bottom	3	0508310657
51	70.3736	122.0011	31-Aug-05	12:02	455	bottom	3	0508311200
52	69.5788	118.0053	31-Aug-05	18:50	400	bottom	3	0508311849
53	68.8506	114.4962	1-Sep-05	00:55	86	bottom	1	0509010054

Table 7. Zooplankton Casts

Net event	Station (CTD Cast)	Latitude (N)	Longitude (W)	Date (UTC)	Time (UTC)	Approx. Max Net Depth (m)	Approx. Water Depth (m)	Notes
1	CB-1 (6)	71.78	131.87	04-Aug-05	7:15	100	1100	
2	CB-1 (6)	71.78	131.87	04-Aug-05	7:31	100	1100	
3	CB-4 (20)	74.98	149.93	10-Aug-05	0:02	100	3830	Contamination: Rinsed inside net with seawater hose
4	CB-4 (20)	74.98	149.93	10-Aug-05	0:11	100	3830	Contamination: Rinsed inside net with seawater hose
5	CB-4 (20)	75.00	150.00	12-Aug-05	12:03	100	3830	Station CB-4 repeated. Location from Bridge Log
6	CB-4 (20)	75.00	150.00	12-Aug-05	12:20	100	3830	Station CB-4 repeated. Location from Bridge Log
7	CB-9 (28)	78.00	149.84	14-Aug-05	6:50	100	3824	
8	CB-9 (28)	78.01	149.84	14-Aug-05	7:07	100	3824	
9	CB-15 (39)	76.98	140.00	26-Aug-05	9:45	100	3700	
10	CB-15 (39)	76.98	140.00	26-Aug-05	10:01	100	3700	

Table 8. Bucket Samples for Surface Water.

*Samples collected include salinity, freshwater alkalinity, $\delta^{18}O$ and barium.

Station Name	Latitude (N)	Longitude (E)	Date (UTC)	Time (UTC)	Water Depth (m)
XCTD 30	77.2933	140.6195	25-Aug-05	15:41	3700+
XCTD 31	76.6651	140.0708	27-Aug-05	03:19	3500+
XCTD 32	76.3713	139.8372	27-Aug-05	06:50	3500+
XCTD 33	75.6632	140.4230	27-Aug-05	16:12	3500+
XCTD 34	75.3342	141.0020	27-Aug-05	19:04	3500+
XCTD 35	74.6724	140.4287	28-Aug-05	05:04	3600+
XCTD 36	74.3403	140.3605	28-Aug-05	07:57	3500+
XCTD 37	73.6656	140.0901	28-Aug-05	23:53	3400+
XCTD 40	72.6638	140.3997	29-Aug-05	09:30	~2900
XCTD 41	72.3337	140.1768	29-Aug-05	11:51	~2700
XCTD 42	72.3084	138.6368	29-Aug-05	20:14	2700+
XCTD 43	72.4264	137.1248	29-Aug-05	23:15	2500+
XCTD 44	72.3647	135.1958	30-Aug-05	09:01	2250
XCTD 45	72.1955	134.2690	30-Aug-05	11:19	2000
XCTD 46	71.9327	132.5862	30-Aug-05	16:12	1200
XCTD 47	71.5878	131.3183	30-Aug-05	22:33	715
XCTD 48	71.5027	130.9598	30-Aug-05	23:33	440
XCTD 49	71.3471	130.7453	31-Aug-05	01:07	152
XCTD 50	70.9200	126.0093	31-Aug-05	06:58	389
XCTD 51	70.3736	122.0011	31-Aug-05	12:02	455
XCTD 52	69.5788	118.0067	31-Aug-05	18:50	400
XCTD 53	68.8506	114.4962	1-Sep-05	00:55	86
Coppermine River 1	67.7206	115.4110	7-Sep-05	23:30	0.5
Coppermine River 2	67.7495	115.3583	8-Sep-05	00:15	0.5
Coppermine River 3	67.7603	115.2653	8-Sep-05	00:45	0.5
Coppermine River 4	67.7947	115.1241	8-Sep-05	01:00	0.5
East of Kugluktuk	68.3678	112.9308	9-Sep-05	03:00	138
West of Cambridge Bay	68.7833	107.9383	9-Sep-05	14:30	88
East of Cambridge Bay	68.8704	105.2838	10-Sep-05	01:00	70
Larsen Sound	70.3425	98.8450	10-Sep-05	15:00	199

3. CTD SETUP SPECIFICATIONS

The two CTD systems onboard are described with relevant laboratory calibration dates. Only the primary system was used.

Primary CTD SBE9plus s/n 0724
Pressure s/n 90559, 29Oct02
Primary Temperature s/n 4322, 25May04, 05Oct04, 24Feb06
Secondary Temperature s/n 4239, 25May04, 05Oct04, 24Feb06
Primary Conductivity s/n 2809, 25May04, 05Oct04, 10Feb06
Secondary Conductivity s/n 2810, 25May04, 05Oct04, 10Feb06
Oxygen (pumped, configured with primary sensors)
s/n 0435 18Mar03, 14Mar05, 16Feb06, A/D voltage 6
Transmissometer Wetlabs s/n CST-662DR, 20Mar03, A/D voltage 2
Fluorometer Seapoint (pumped, configured with secondary sensors) s/n 2569 gain set at 30x (hope correct cable was used) A/D voltage 0
Altimeter Datasonics PSA-916D #1161, A/D voltage 4
Primary Pump s/n 053610
Secondary Pump s/n 053615

Backup CTD SBE9plus s/n 0756
Pressure s/n 91164, 18Mar04
Primary Temperature s/n 4397, 12Mar04
Secondary Temperature s/n 4402, 06Mar04
Primary Conductivity s/n 2992, 11Mar04
Secondary Conductivity s/n 2984, 11Mar04

Heights and Dimensions:
Measurements made in 2004, setup similar for 2005
Intake of temperature probes 7" above bottom of frame.
LADCP base 2" above bottom of frame
Temperature probes 8" apart
Transmissometer is mounted above the CTD, in obstructed flow.
Bottom of Niskin 10" above bottom of frame
Top of Niskin is 45" above bottom of frame
Bottle center is 10 + 35/2 = 27.5" above the bottom of the frame
Bottle center is 27.5"-7" = 20.5" (0.52m) above the sensors intakes.

4. CTD CAST NOTES AND LIST OF INTERPOLATIONS

Table 9. Comments on CTD Casts

Cast #	Station Name	Comments
1	1	
2	2	
3	3	
4	4	
5	AG5	Comm error when bottle 9 fired. CTD stopped. Bottle actually did fire at the right time.
6	CABOS	Cast 2 miles away from CABOS mooring. Chl Max at 80, so took a 50m bottle anyway.
7	CABOS	Bottle flushing test: stop for 30s, up 1m, down 2m, up 1m, wait 30s, trip.
8	CABOS	Sampling test, 3 niskins per depth, 30s, 2min, 5min waits.
9	CB-28B	Station name changed from CB2 to CB28B.
10	CB-28A	Station name changed from CB1B to CB28A. Winch stopped at 900m on down and up casts to change gears. Duplicate CFC#113, Syringe 7678 was drawn after DO. Drip on bottle 8 may be spigot O-ring. Processing Notes: Sample 113, Niskin 24, intended pressure 2105db, although it did not close until the surface. All chemistry (S,O,Nuts,Alk,O^{18},CFC) support using same CTD info as Niskin 1 (sample 136). CTD data changed and QC codes changed for chemistry.
11	BS3-A	
12	BS3	Comm error on tripping bottles 4,5,6. Actual trip depths: Difficult to find clear water to deploy rosette in heavy broken ice.
13	BS3-B	Cesium cast. Bottles tripped after 2 minute stop. No sounder trace.
14	BS3-B	Comm error while tripping first bottle - bottle 25 (?) closed. Cast repeated after work on CTD. No Chl max. Processing Notes: Sample186, Niskin 20, intended pressure 26db. Chemistry varies (S, Ox, O18 are all OK; Nuts are quest). Leave CTD data as they are.
15	BS3-C	Comm error on tripping first bottle - bottle 25 closed. After this, go to user input bottle firing. Upcast in second file 2005-04_015up.
16	BS3-D	Stop at 900m down and up to change gears on the winch. Altimeter cut in at 27m off bottom.
17	CB2	Max depth 3564m, about 60m off bottom because of problems with the winch brake at depth.
18	CB3	Stopped at 327m on the way down to diagnose transmissometer error.
19	CB3	DO value stuck in Seasave readout, so bring rosette up from 900m and restart cast. Cast numbers 19 are 0-9000m, 19a 900-0m and 19b full cast. Stop at 900m on down and up casts to change winch gears. With smoother winch operation. Altimeter came on at 92m off bottom.
20	CB4	Stop at 900m on down and up casts to change winch gears. Pressure spike and other data errors at 320m on downcast. Speed variations between 900 and 1100m due to trying to adjust the winch brake.
21	CB-5	Problems with transmissometer on downcast between 260 and 370m not seen on upcast. Bottle 1 had comm error on tripping.
22	CB-5A	Pressure readout in Seasave stuck at 546m both in fixed and graph displays but depth value continues to change. Couldn't read in air pressure after cast because of this. 2 Releases on frame; stopped at 3802m on upcast to test them (failed). Two sparrow-like birds fying around the ship. Bottom cap did not close on bottle 24.
23	CB-5B	

Cast #	Station Name	Comments
24	CB-6	Transmissometer, altimeter detached from CTD and LADCP was not turned on to test 3 mooring releases. Tests failed last cast so potential sources of acoustic interference have been shut down. Transmissometer repositioned. It was left off to verify it is not interfering with operation of the DO probe. Repositioning may affect its flaky behaviour if that is due to twisting. Stooped at 3786m on the upcast to test releases (they were OK) Stopped at 750 on upcast the change winch gears.
25	CB4	In Seasave, plotting error at 100m: T,S,Do offset. Restarted window and offset went away. Bottle 7 did not trip: was sent signal twice and confirmation came back on second try but bottle never closed.
26	CB7	
27	CB8	Bottle 8 switched out with a spare before cast. Releases on frame, so altimeter off for the cast. On deployment, Seasave pressure readout was stuck; redeployed, restarted Seasave and all OK. Discharge of water from the ship under the A-Frame - evaporator waste, so higher salinity than ambient. Discharge stopped at 1954 UTC. Winch stopped at 900m on down and up casts to change gears.
28	CB9	Second set of TOC's taken to test alternate analysis method.
29	CB11	DO sensor reading less than 4 at oxygen minimum. Comm error when closing bottle 1; closed OK on second try. Wnet back down from 100m to 141m to catch 33.5 PSU; possible that increased pressure may have affected bottles 1-9, already closed.
30	CB11	Stop at 900m on down and up casts to change winch gears. Stop at 629m on upcast because of winch spooling error; spooling fixed next cast.
31	Ice_flow	
32	CB-10	
33	CB-10	
34	CB-10a	
35	CB-10b	
36	CB-9	Bottle 15 did not close (received confirmation).
37	CB12	
38	CB13	Bottle 15 did not close (received confirmation). Processing Notes: Sample 616: Niskin 20, intended pressure 95db. CTD changed to match sample 617, Niskin 21, 79db. Most chemistry supports this (S, Ox, Nuts, Alk) however CFCs do not.
39	CB15	
40	CB15	Cesium Cast for samples 652 to 666 and Salt Cal Cast (30sec stop, raise 1 m, lower 2m, raise 1m) for samples 667 to 671; Bottle 10, sample 661 - stopped too shallow, lowered 2m.
41	CB15	
42	CB17	
43	CB18	Releases on frame for testing; stop at 3625m for 10 minutes or so. Oxygen displayed value stuck at 4.62 but recorded on disk properly. CDOMs left out of fridge and exposed to light for ~8 hours.
44	CB21	
45	CB27	Cups squeezing cast - they got pulled up through the block after the 3 minute acclimatisation. Bacteria sample number 776 was not checked on rosette sheet but taken because a label was made for it. Processing Notes: Sample 776: Niskin 13, intended pressure 221db. Chemistry varies, pointing to 221(S,O18), 235(Ox), 221-235(Nuts), Shallower (Alk, CFC). Flag as bad bottle and remove final data.
46	CB29	Jellyfish on rosette.

Cast #	Station Name	Comments
47	CB23a	Cup squeezing cast. Bottle 23 at 25m took 3 tries with Sesave user input to confirm firing. Depth at confirmation ~17m but rosette file shows 25m.
48	CB31a	
49	CABOS	Bottle 23 at 25m took two tries to confirm tripping. Stopped at 11m on upcast to see if we could get a discharge near the rosette stopped. It was glley garburator material but appeared to be drifting aft away from the rosette.
50	CB1a	Bottles shallower than 25 would not trip using Seasave. sDeck unit firing not tried during the cast but on deck afterward they fired fine.

Table 10. List of linear interpolations made to downcast CTD data.

Cast	Start (db)	Stop (db)	Interval (db)	Property
1	1	3	2	Temperature and Conductivity
1	205	207	2	Temperature and Conductivity
2	1	8	7	Temperature and Conductivity
2	18	20	2	Temperature and Conductivity
2	38	39	1	Temperature and Conductivity
4	91	93	2	Temperature and Conductivity
5	1	5	4	Temperature and Conductivity
5	0	2	2	Oxygen
5	12	14	2	Temperature and Conductivity
6	6	11	5	Temperature and Conductivity
6	25	27	2	Temperature and Conductivity
7	0	3	3	Temperature and Conductivity
8	0	2	2	Temperature and Conductivity
9	0	3	3	Temperature and Conductivity
11	6	8	2	Temperature and Conductivity
11	10	13	3	Temperature and Conductivity
11	13	20	7	Temperature and Conductivity
11	90	91	1	Temperature and Conductivity
12	6	8	2	Temperature and Conductivity
12	9	13	4	Temperature and Conductivity
12	18	21	3	Temperature and Conductivity
12	41	43	2	Temperature and Conductivity
12	122	126	4	Temperature and Conductivity
13	1	6	5	Temperature and Conductivity
15	3	12	9	Temperature and Conductivity
15	280	282	2	Temperature and Conductivity
15	314	317	3	Temperature and Conductivity
15	911	914	3	Temperature and Conductivity
16	10	14	4	Temperature and Conductivity
17	1	6	5	Temperature and Conductivity

Cast	Start (db)	Stop (db)	Interval (db)	Property
18	3	6	3	Temperature and Conductivity
18	0	2	2	Oxygen
18	270	272	2	Temperature and Conductivity
19	1	3	2	Temperature and Conductivity
19	6	10	4	Temperature and Conductivity
19	13	15	2	Temperature and Conductivity
19	238	240	2	Temperature and Conductivity
19	242	244	2	Temperature and Conductivity
20	11	17	6	Temperature and Conductivity
20	321	324	3	Temperature and Conductivity
21	7	12	5	Temperature and Conductivity
21	318	320	2	Temperature and Conductivity
22	6	8	2	Temperature and Conductivity
22	9	11	2	Temperature and Conductivity
22	12	14	2	Temperature and Conductivity
22	306	309	3	Temperature and Conductivity
23	0	3	3	Temperature and Conductivity
24	5	7	2	Temperature and Conductivity
24	10	12	2	Temperature and Conductivity
24	16	19	3	Temperature and Conductivity
24	3872	3873	1	Temperature and Conductivity
25	1	8	7	Temperature and Conductivity
25	10	15	5	Temperature and Conductivity
25	19	22	3	Temperature and Conductivity
25	28	30	2	Temperature and Conductivity
25	40	120	80	Use secondary temperature and conductivity instead of primary (no interpolation performed)
26	10	13	3	Temperature and Conductivity
26	14	17	3	Temperature and Conductivity
27	1	4	3	Temperature and Conductivity
27	947	949	2	Temperature and Conductivity
28	0	4	4	Temperature and Conductivity
28	412	580	168	Use secondary temperature and conductivity instead of primary (no interpolation performed)
29	1	4	3	Temperature and Conductivity
30	1	3	2	Temperature and Conductivity
30	345	348	3	Temperature and Conductivity
30	910	914	4	Temperature and Conductivity
31	0	2	2	Oxygen
31	2	4	2	Temperature and Conductivity
31	271	273	2	Temperature and Conductivity
32	8	14	6	Temperature and Conductivity
33	24	26	2	Temperature and Conductivity
33	27	30	3	Temperature and Conductivity
34	0	15	15	Temperature and Conductivity

Cast	Start (db)	Stop (db)	Interval (db)	Property
34	15	20	5	Temperature and Conductivity
35	3151	3153	2	Oxygen
35	4	9	5	Temperature and Conductivity
36	6	11	5	Temperature and Conductivity
36	352	354	2	Temperature and Conductivity
37	12	18	6	Temperature and Conductivity
38	5	10	5	Temperature and Conductivity
39	1	7	6	Temperature and Conductivity
39	911	913	2	Temperature and Conductivity
41	6	8	2	Temperature and Conductivity
41	12	14	2	Temperature and Conductivity
41	16	18	2	Temperature and Conductivity
41	602	603	1	Temperature and Conductivity
42	2	4	2	Temperature and Conductivity
42	9	12	3	Temperature and Conductivity
42	15	19	4	Temperature and Conductivity
42	1013	1019	6	Temperature and Conductivity
43	1	6	5	Temperature and Conductivity
43	446	448	2	Temperature and Conductivity
43	3707	3717	10	Oxygen
44	3	13	10	Temperature and Conductivity
44	911	914	3	Temperature and Conductivity
46	1	16	15	Temperature and Conductivity
48	270	272	2	Temperature and Conductivity
49	1	5	4	Temperature and Conductivity
50	1	3	2	Temperature and Conductivity
50	8	10	2	Temperature and Conductivity

Table 11. List of linear interpolations made to upcast CTD data.

Cast	Start (db)	Stop (db)	Interval (db)	Property
12	149	152	3	Oxygen
19	3885	3888	3	Oxygen
25	909	912	3	Oxygen
28	3891	3893	2	Oxygen
42	1012	1018	6	Oxygen

5. INDIVIDUAL STATION PLOTS

The following section contains data plots for each CTD cast taken on the 2005-04 cruise. CTD and chemistry data are plotted in eight figures per cast with primary CTD properties on the even pages and chemistry properties on the odd pages.

Table 12. Property legend for the following individual station plots.

┈┈	**Salinity (PSU), CTD**
▲	**Salinity (PSU), Bottle**
—	**Theta (°C)**
◇	**CFC 12 (nmol/m^3)**
▶	**CFC 11 (nmol/m^3)**
◁	**Silicate (mmol/m^3)**
······	**Transmissometer (%/m)**
—	**Fluorescence (mg/m^3)**
●	**Chlorophyll-a (mg/m^3)**
◁	**Phosphate (mmol/m^3)**
▲	**Nitrate (mmol/m^3)**
○	**Silicate (mmol/m^3)**
—	**Oxygen (mmol/m^3), Sensor**
■	**Oxygen (mmol/m^3), Bottle**
▶	**Barium (µmol/m^3)**
◇	**O^{18} (‰)**
▶	**Alkalinity (µmol/kg)**

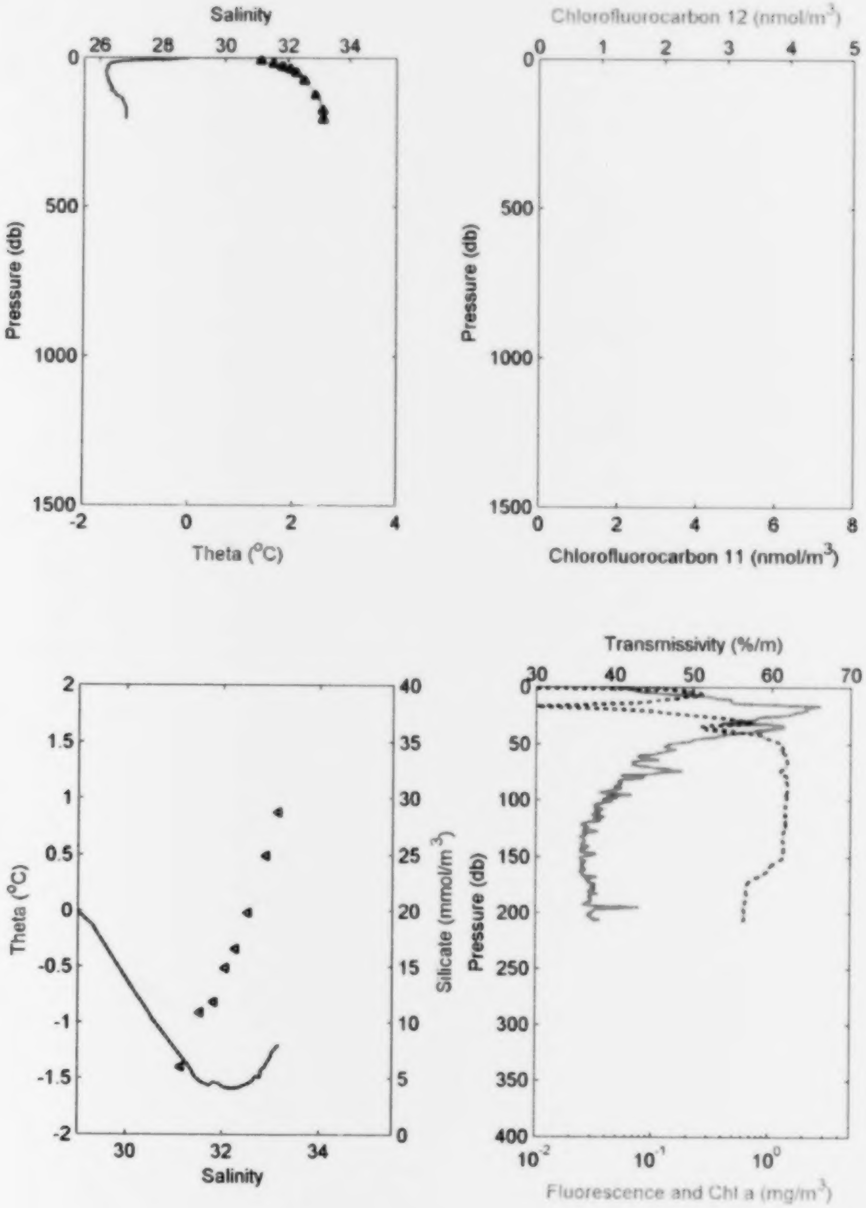
◁	**Cesium (Bq/m^3)**
■	**Iodine-129 (10^7 atom/L)**

◁	**DIC (µmol/kg)**
▲	**Alkalinity (µmol/kg)** **(from DIC bottle)**

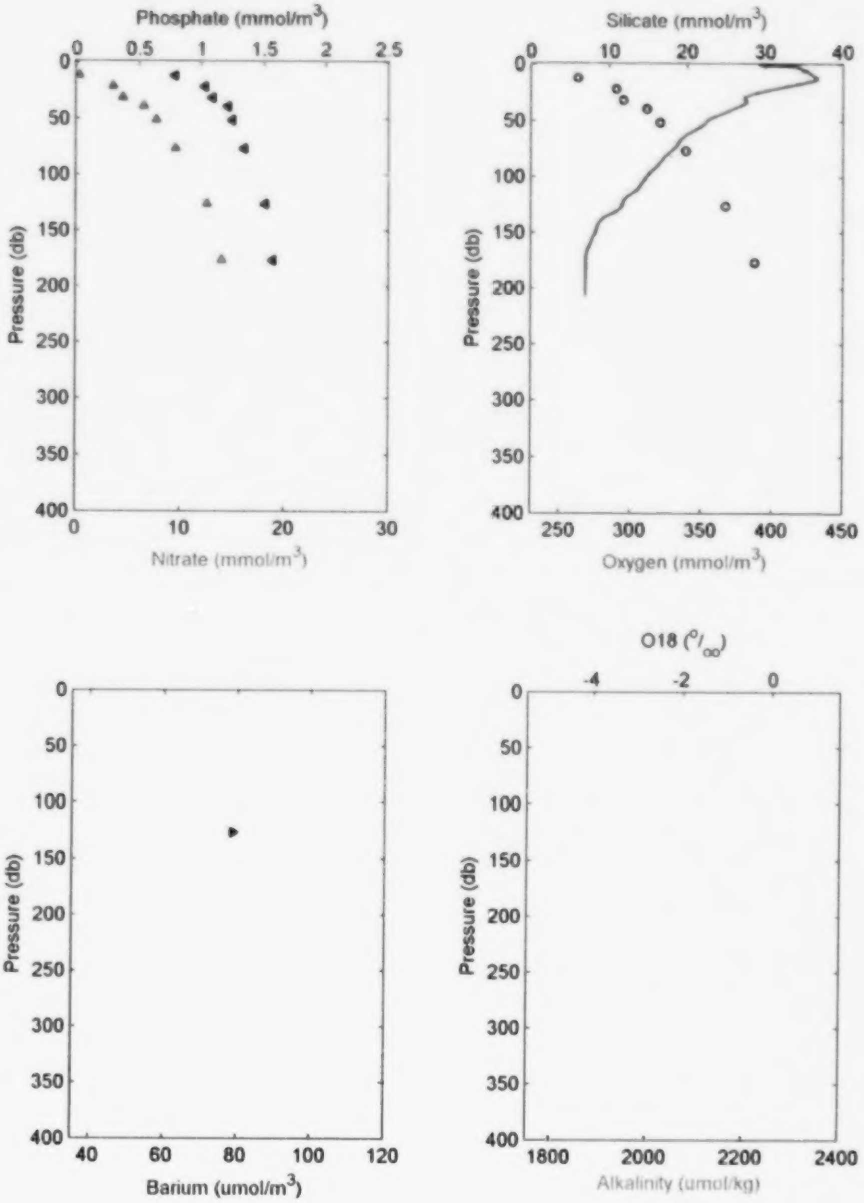
▲	**TOC (mmol/m^3)**

5.1 Standard

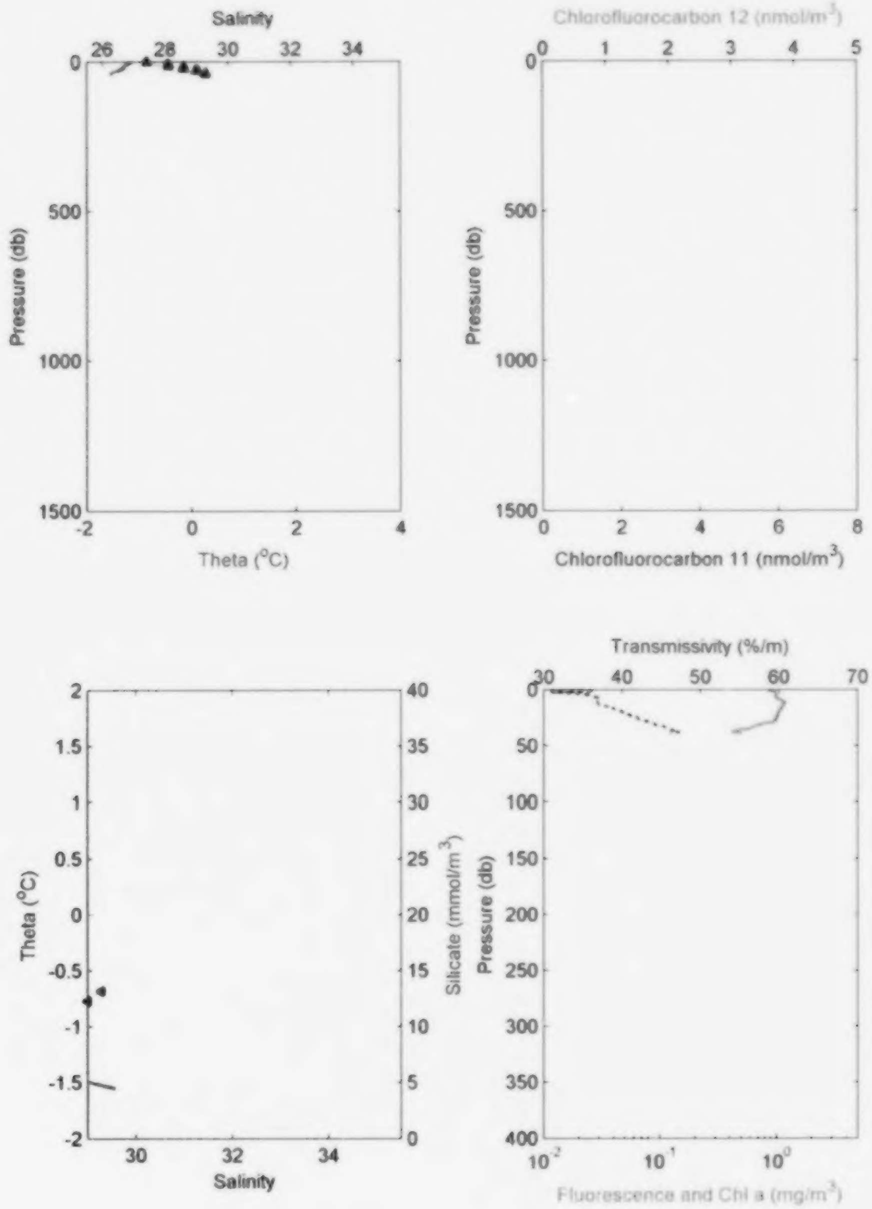
2005-04: Cast 1 Station 001



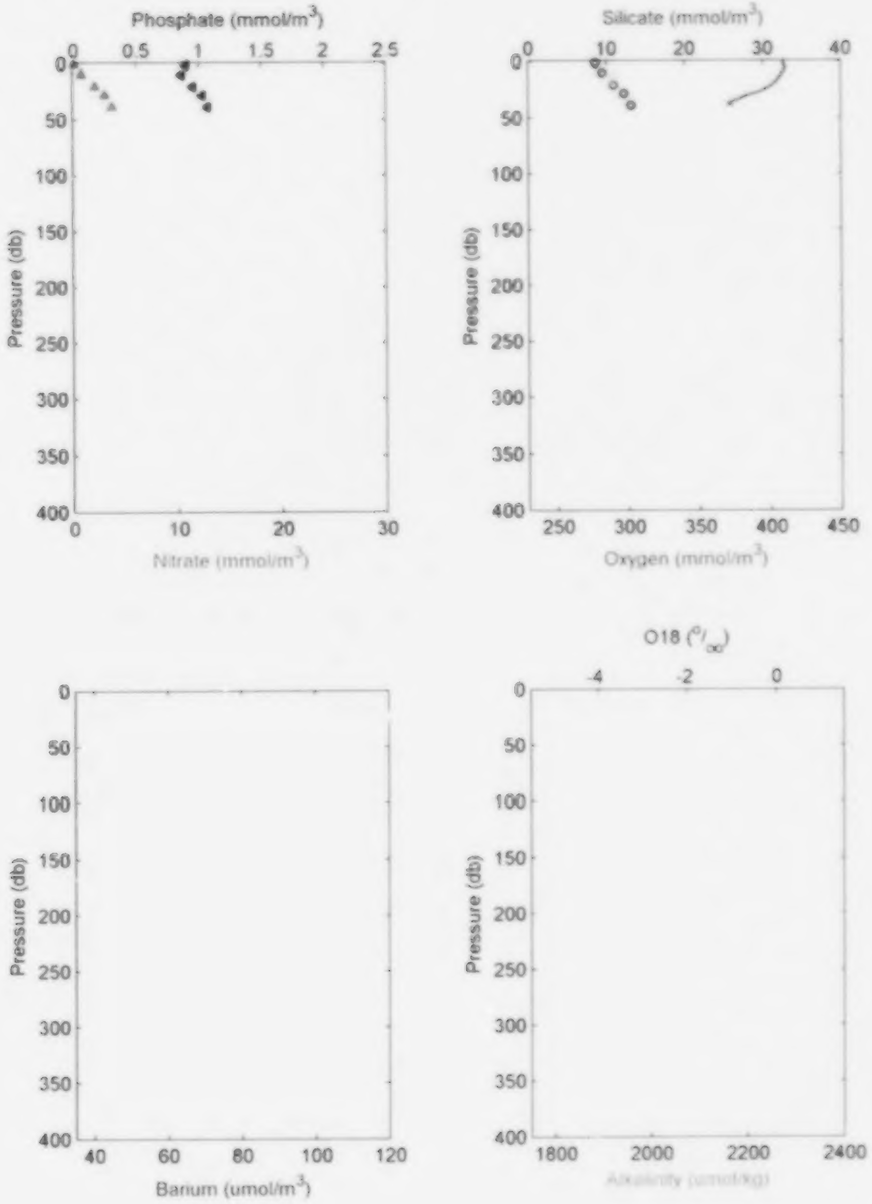
2005-04: Cast 1 Station 001



2005-04: Cast 2 Station 002



2005-04: Cast 2 Station 002



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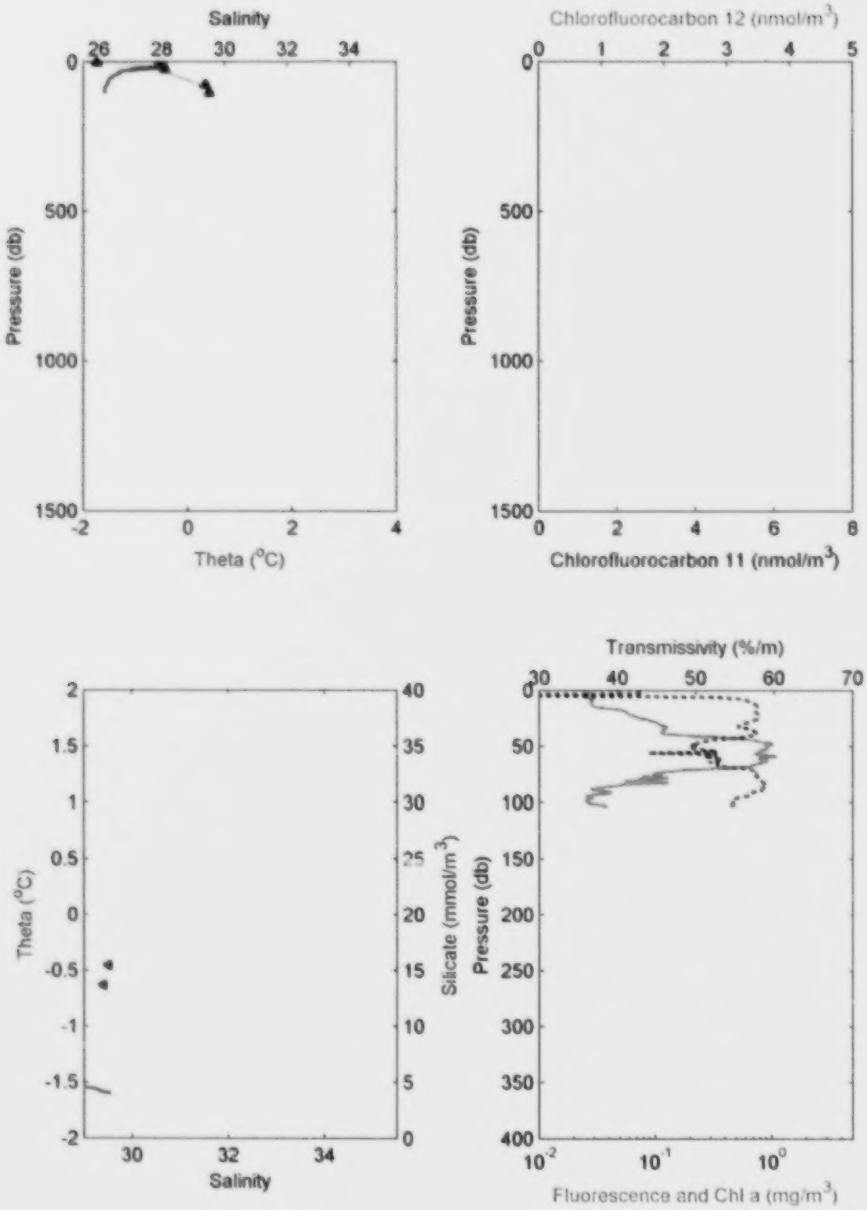

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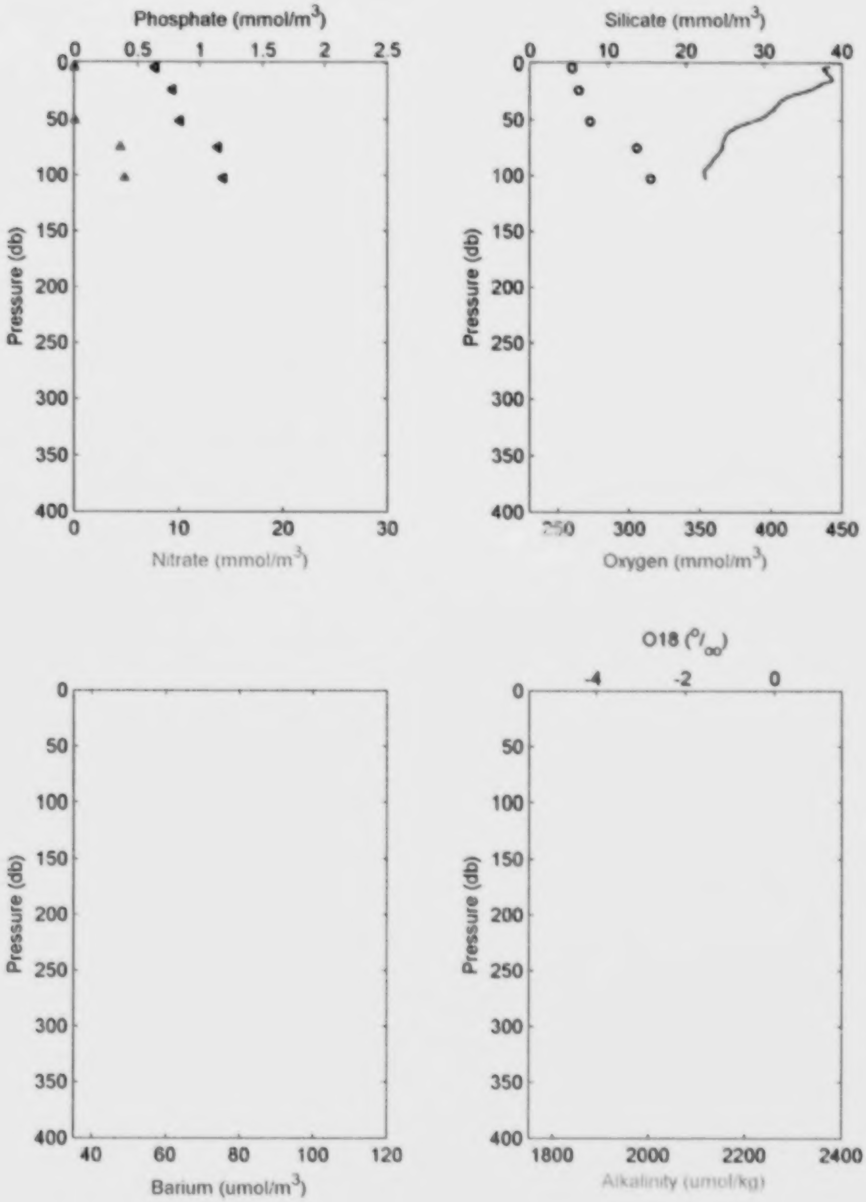

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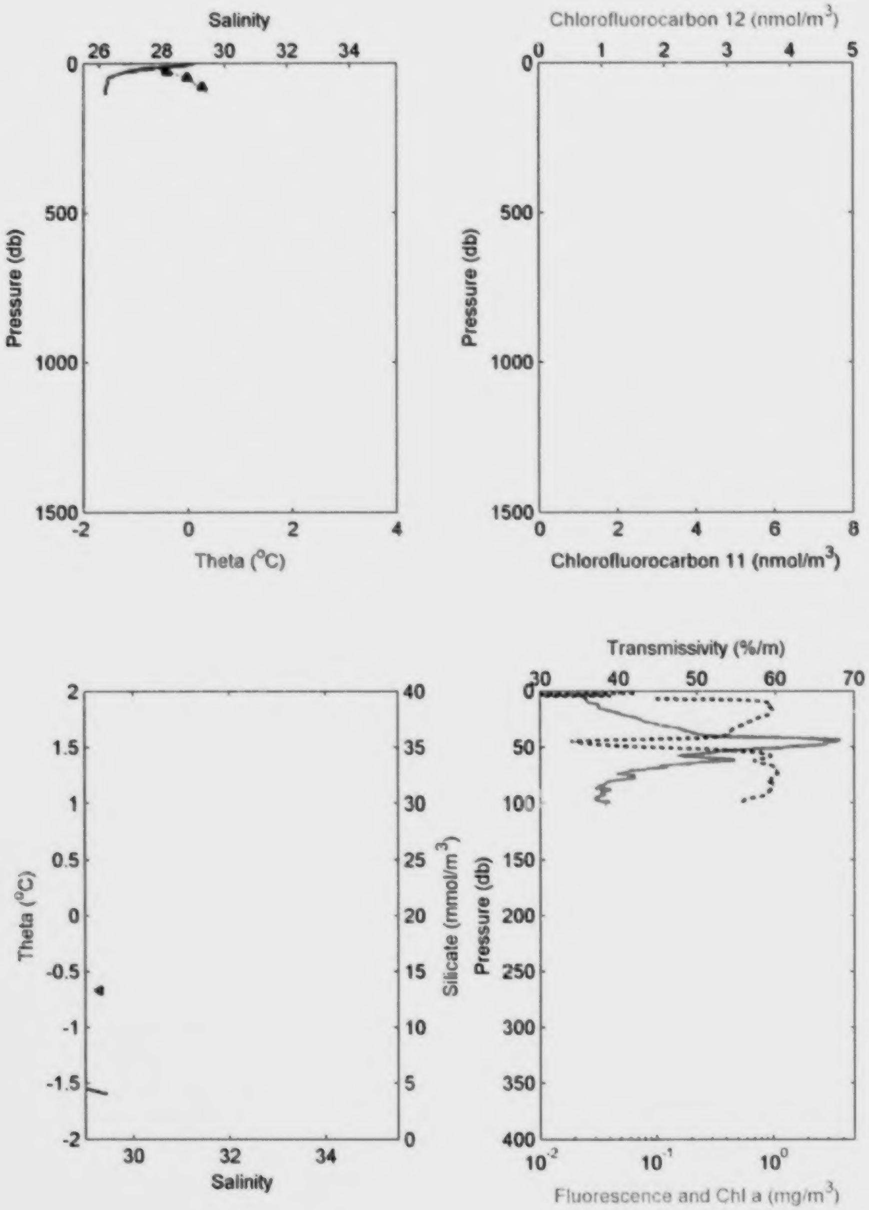

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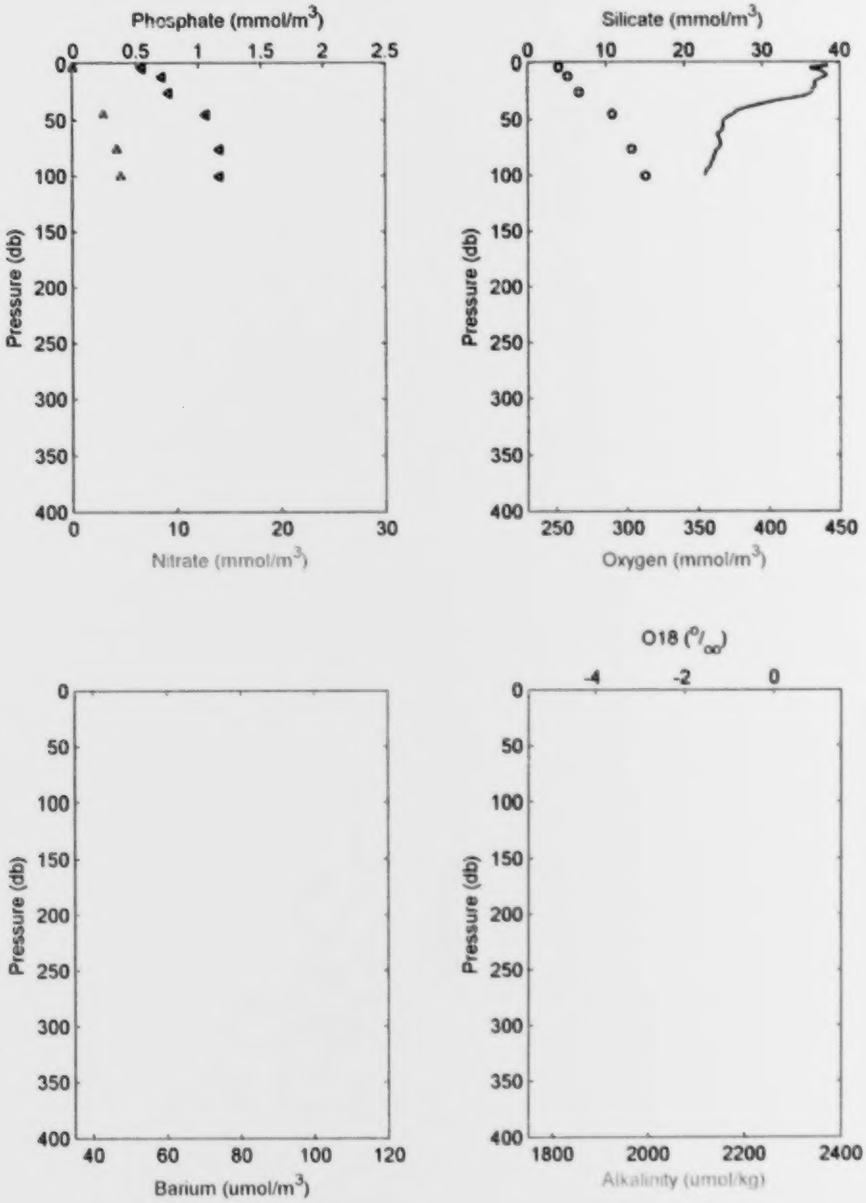

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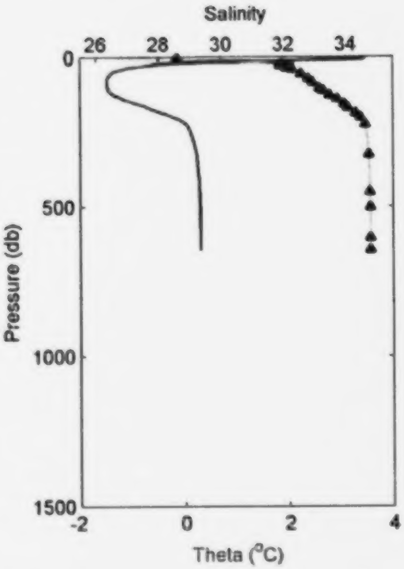

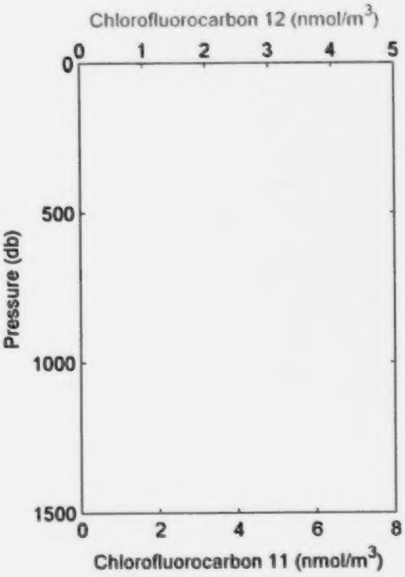

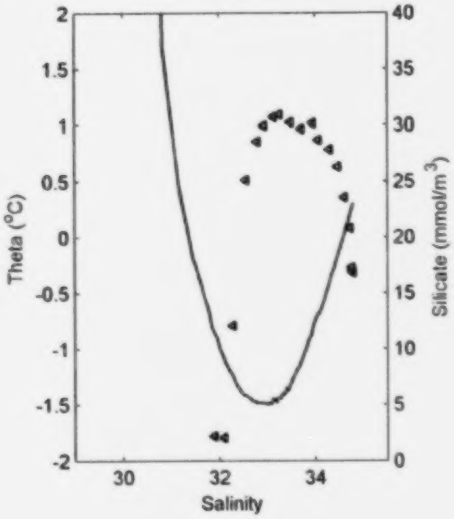

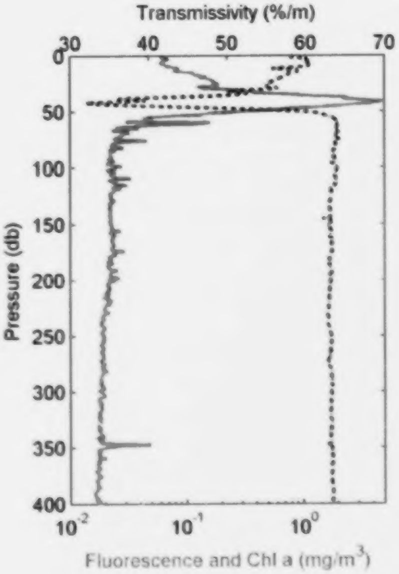

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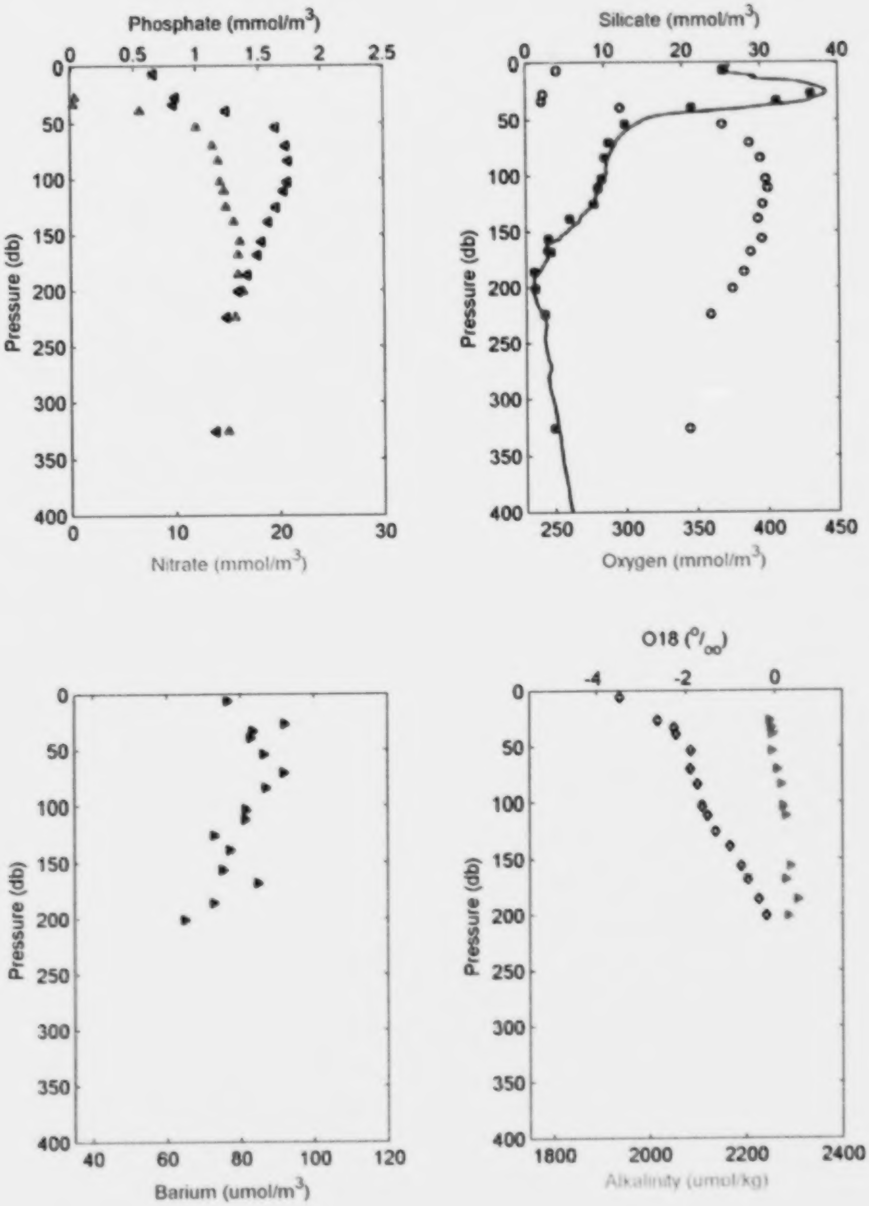
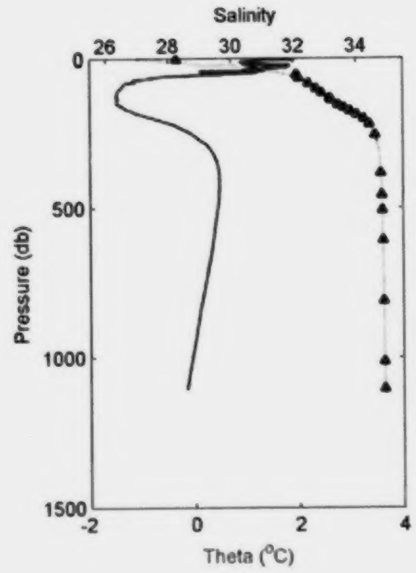
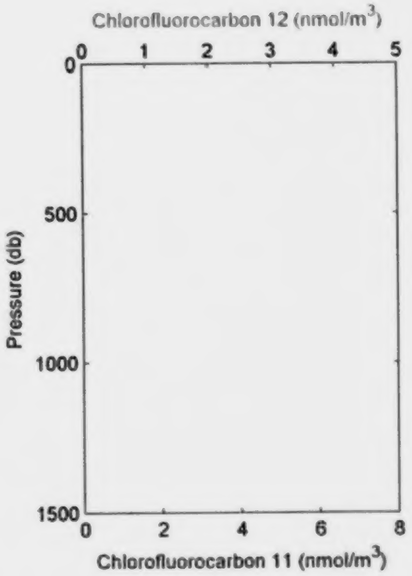
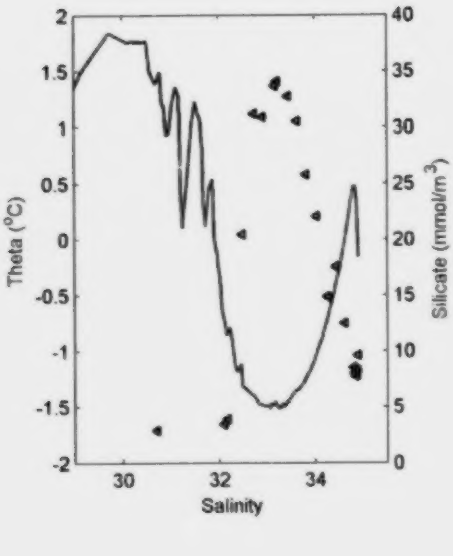
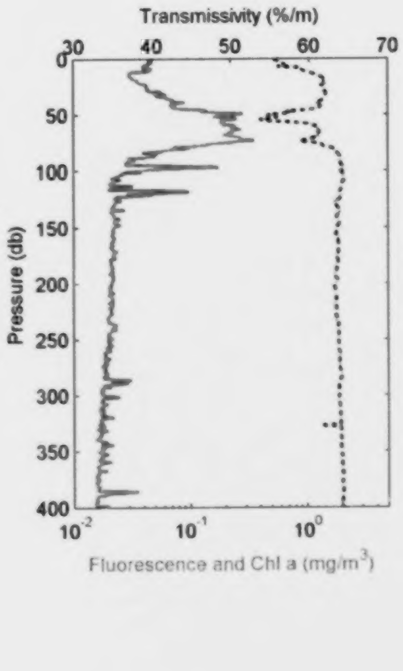


2005-04: Cast 6 Station CABOS

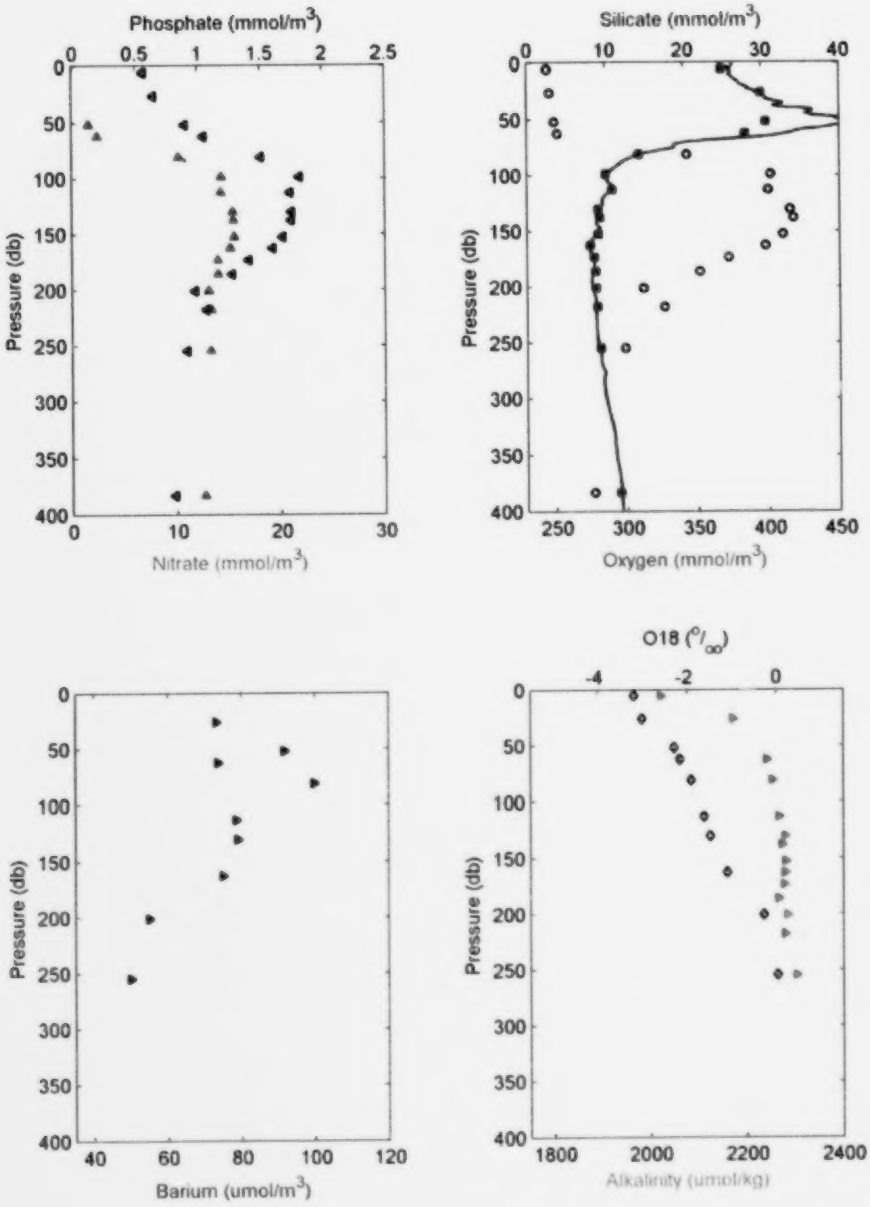




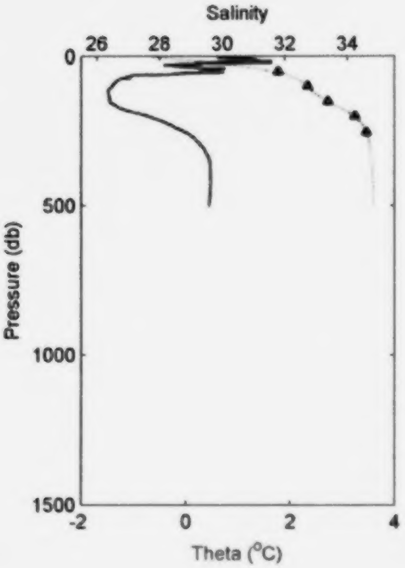


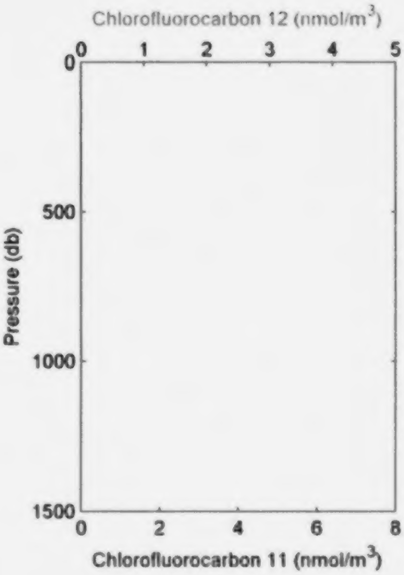


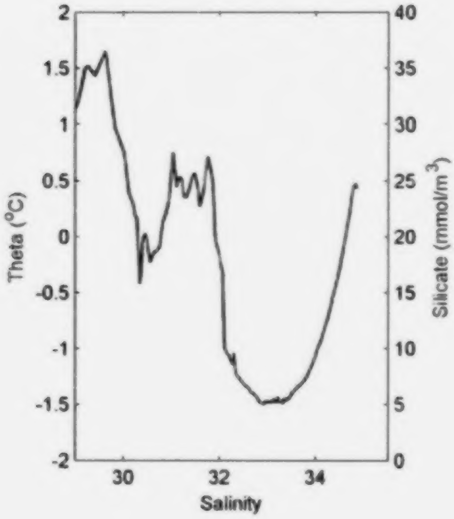
2005-04: Cast 6 Station CABOS

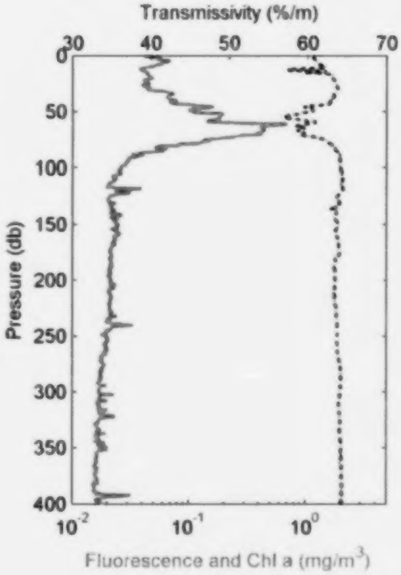


2005-04: Cast 7 Station CABOS









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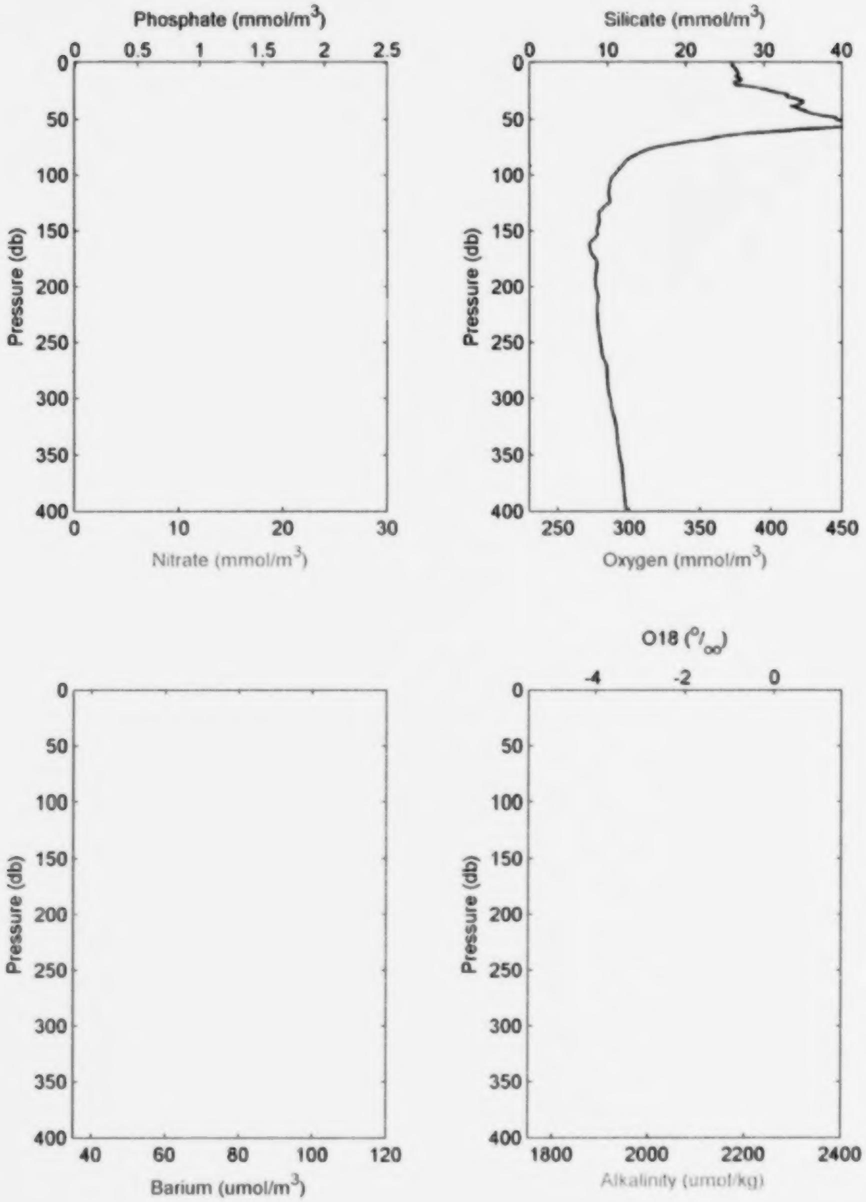
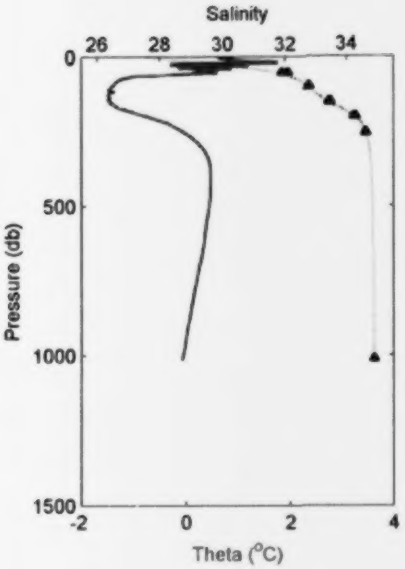
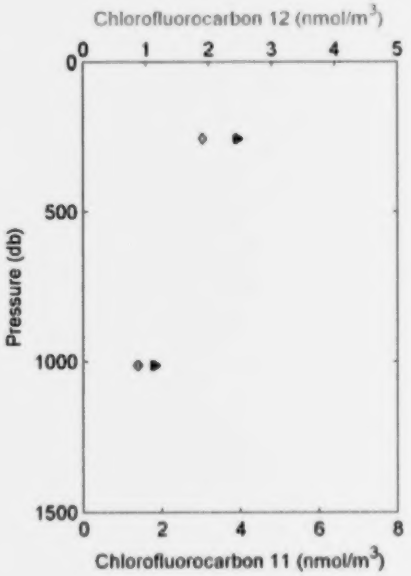
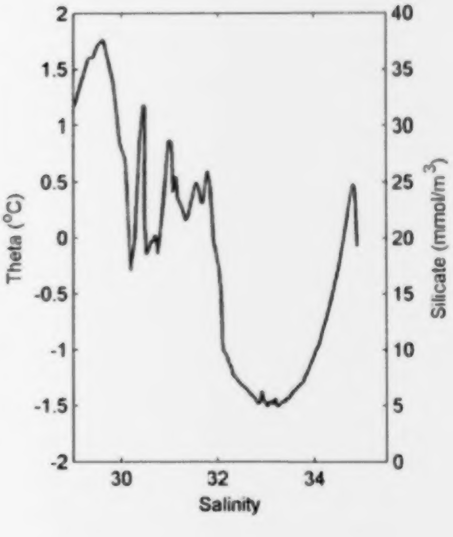
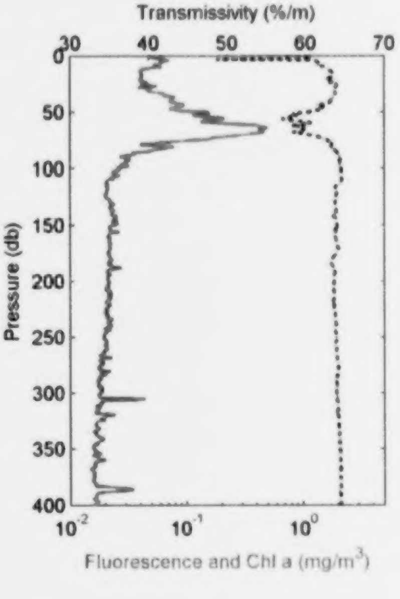


2005-04: Cast 8 Station CABOS

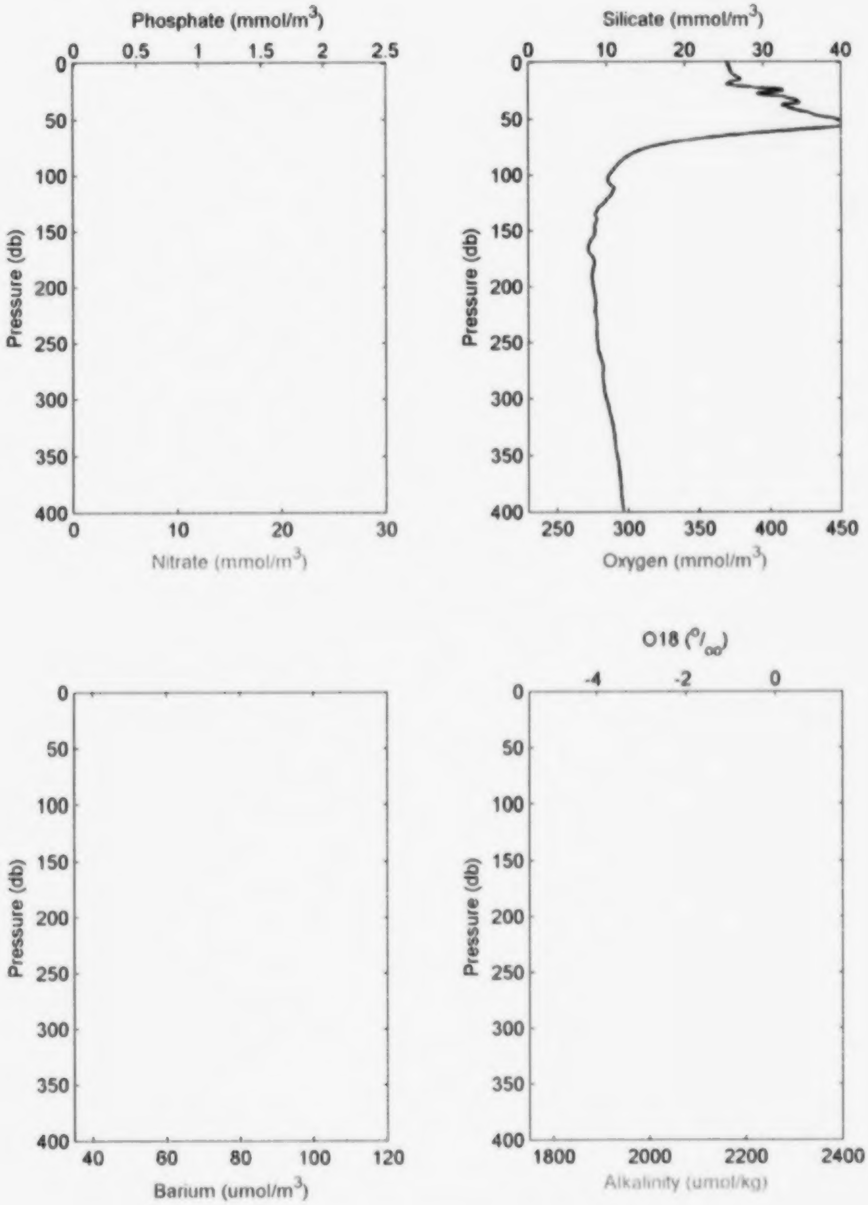




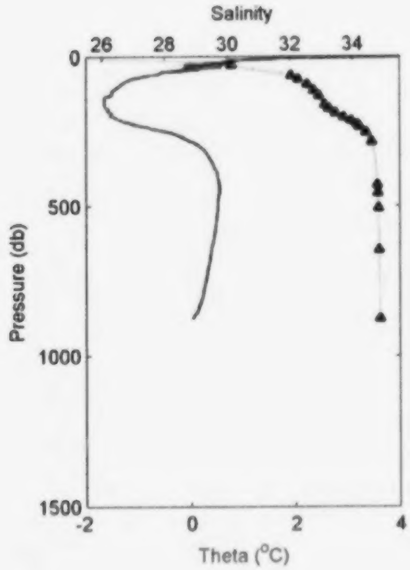


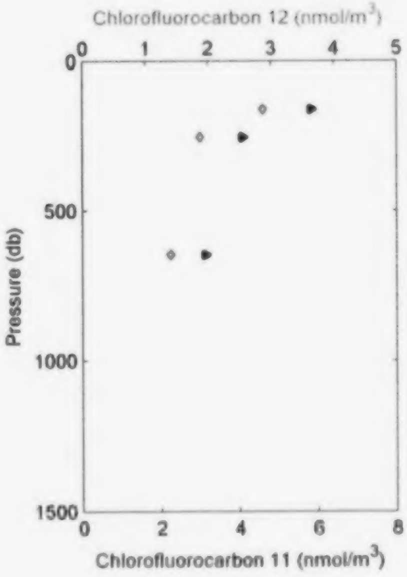


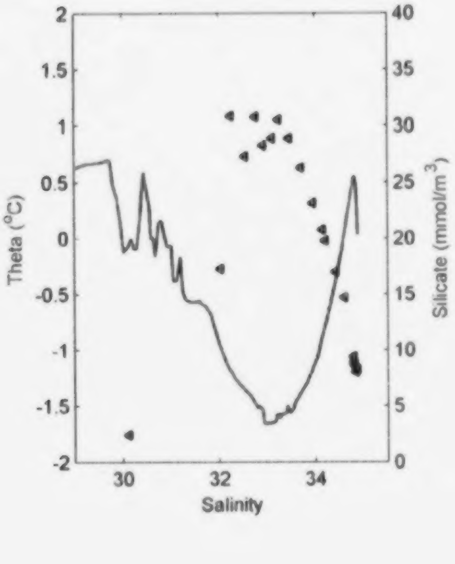
2005-04: Cast 8 Station CABOS

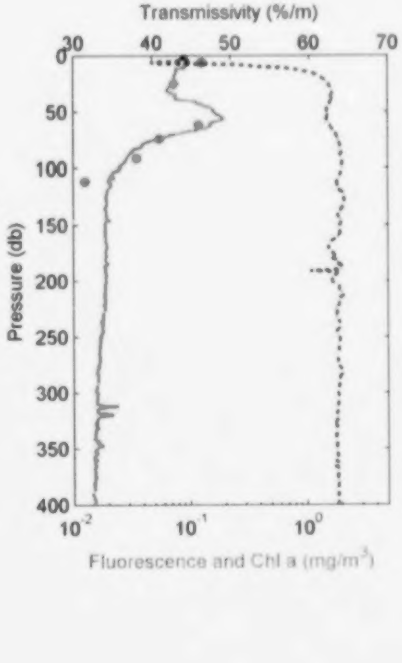


2005-04: Cast 9 Station CB28B









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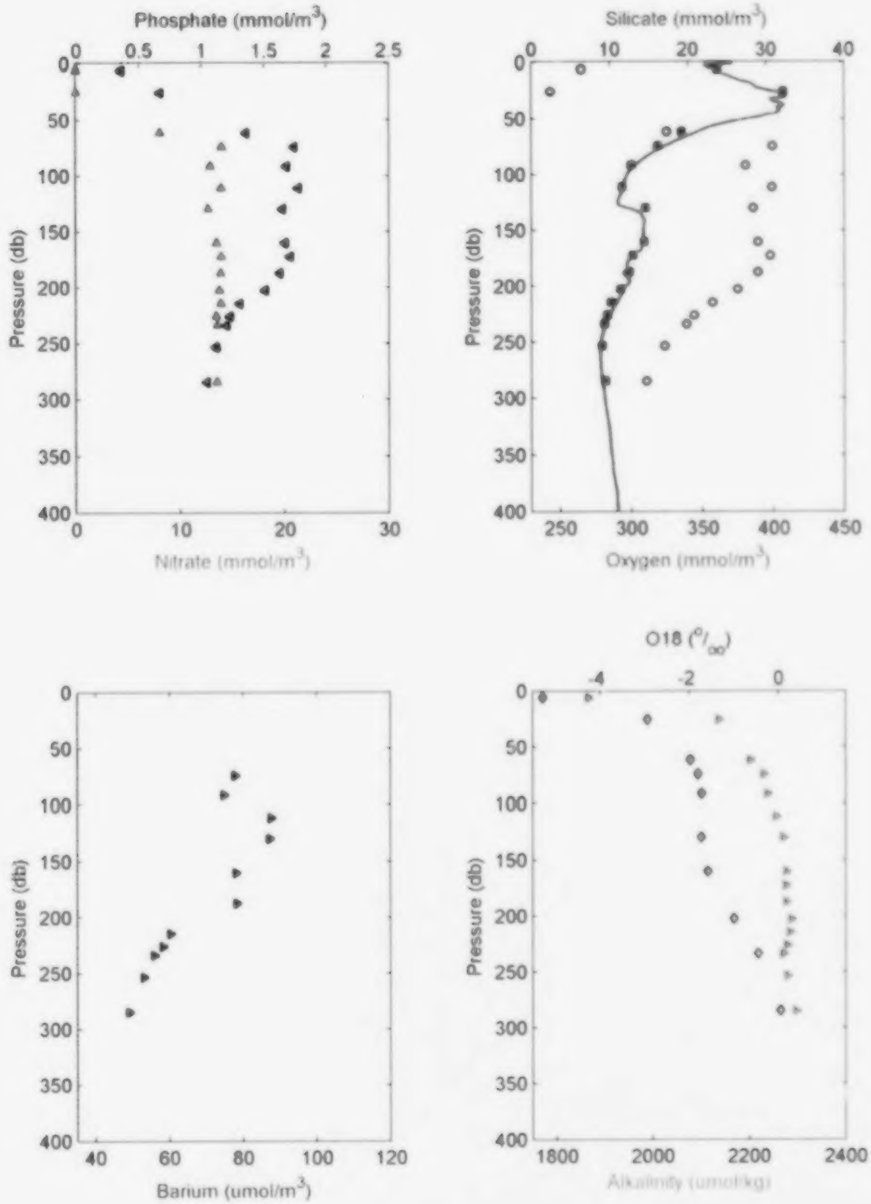
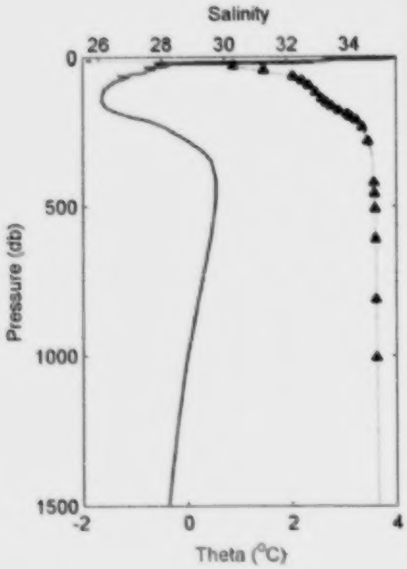
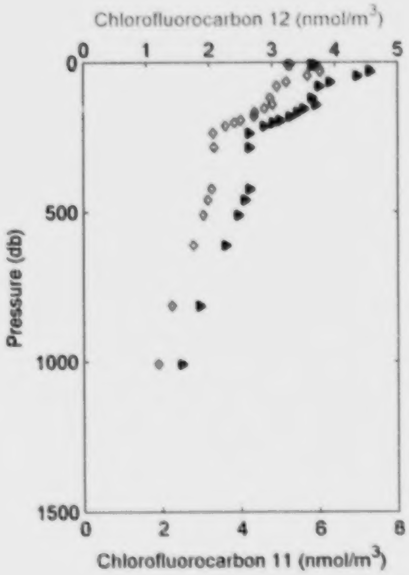
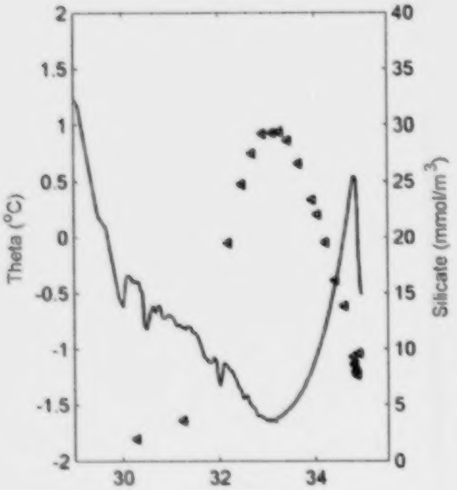
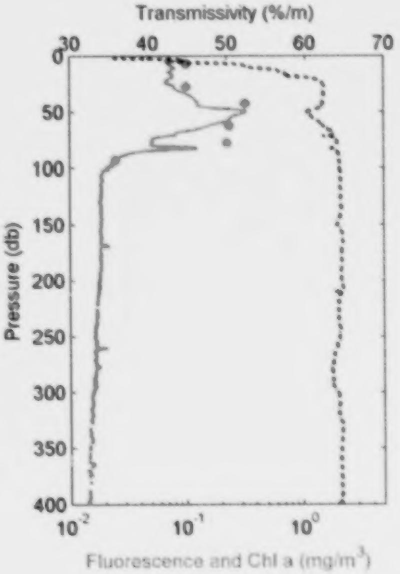


2005-04: Cast 10 Station CB28A









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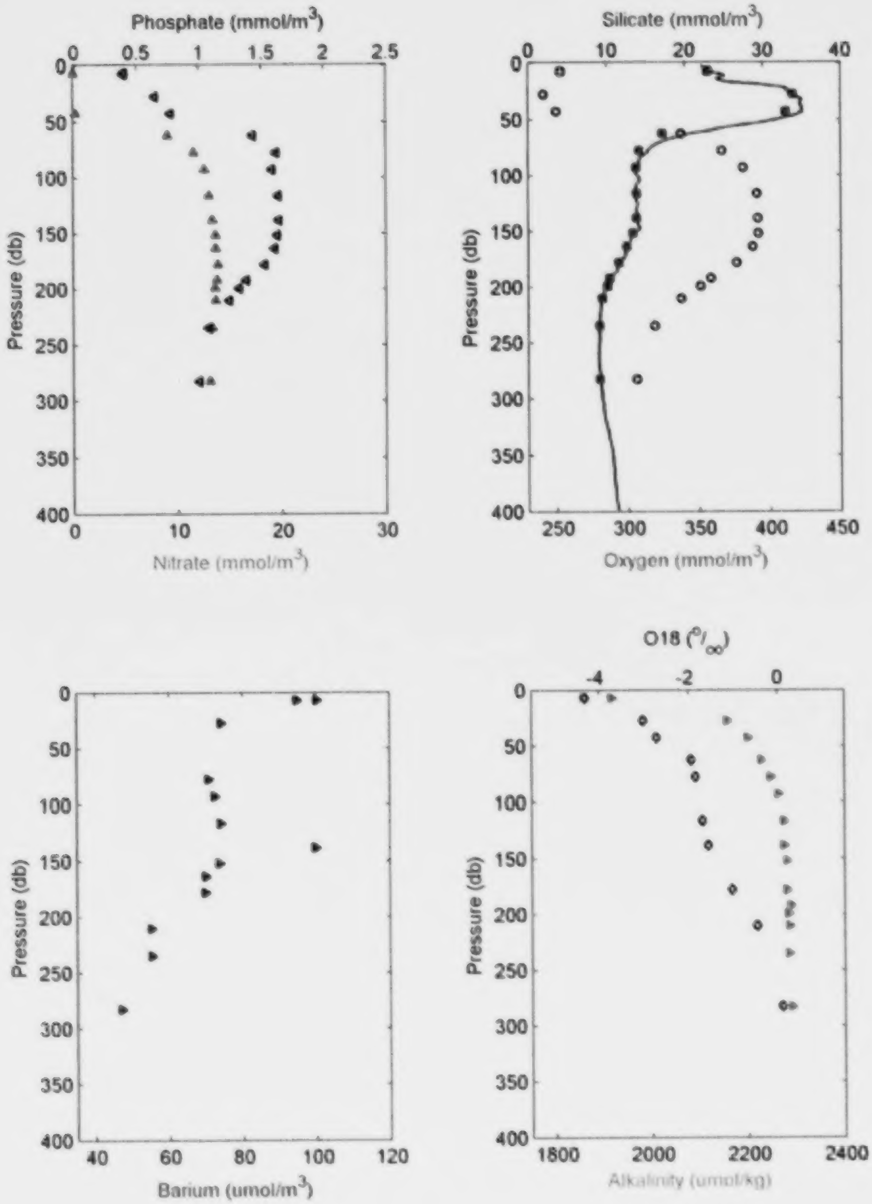
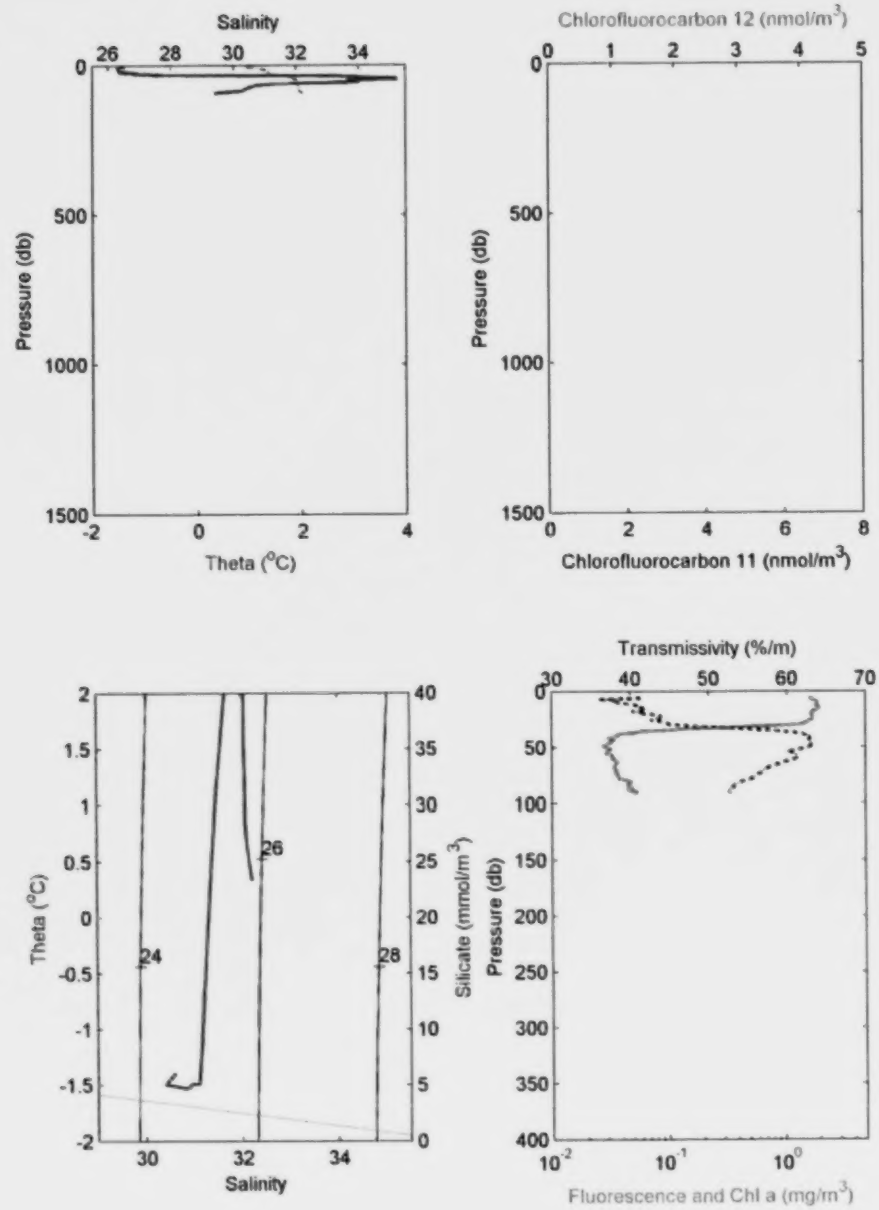


2005-04: Cast 11 Station BS3A



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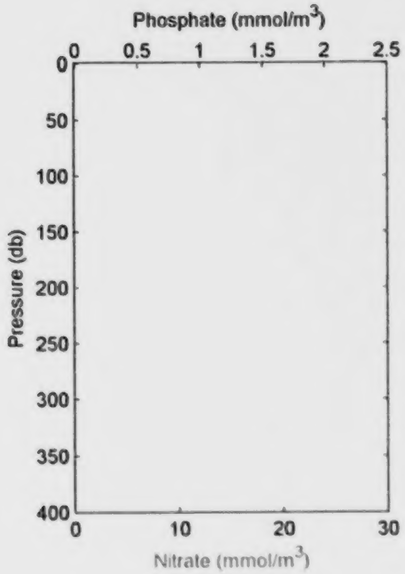
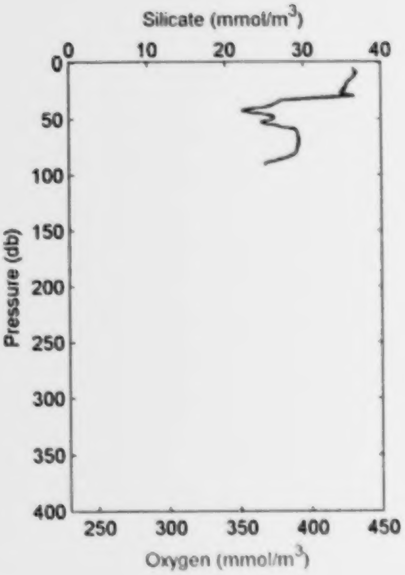
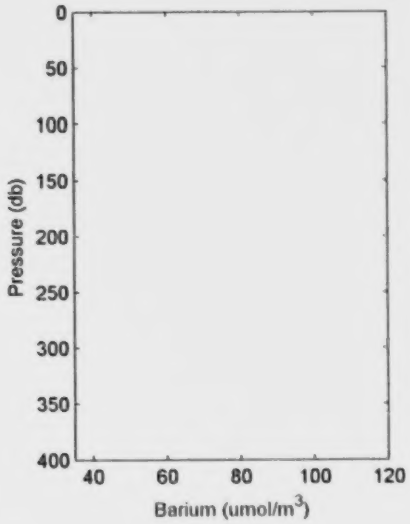
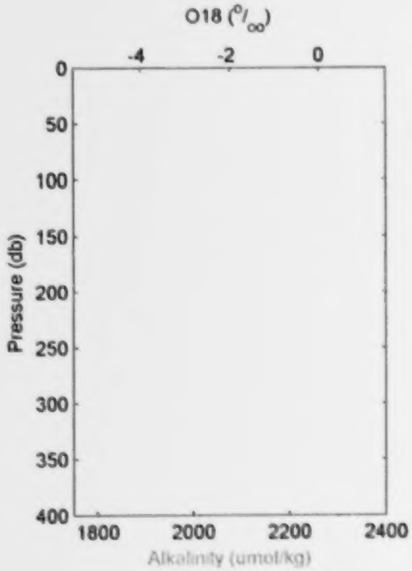
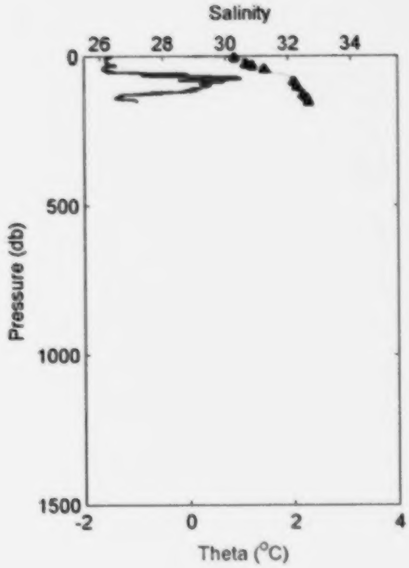


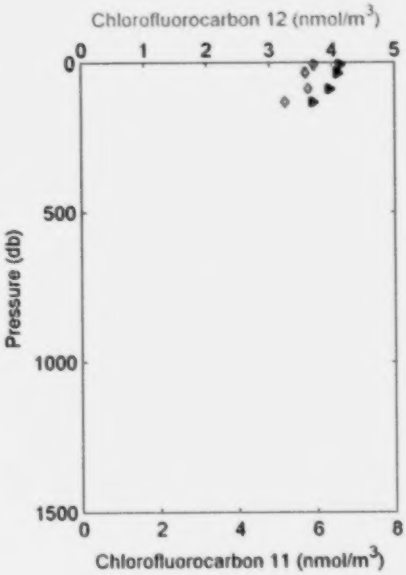


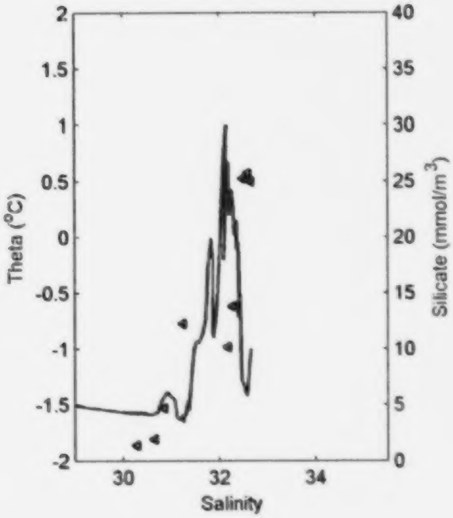


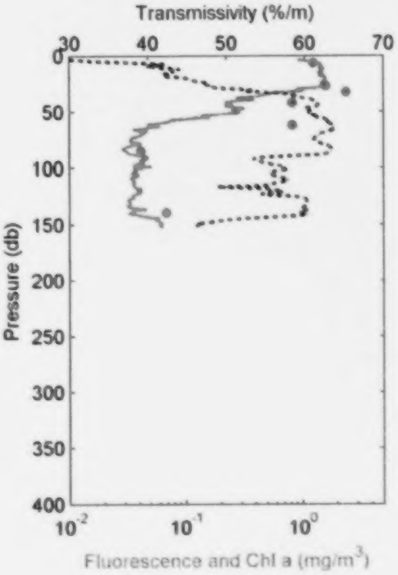


2005-04: Cast 12 Station BS3

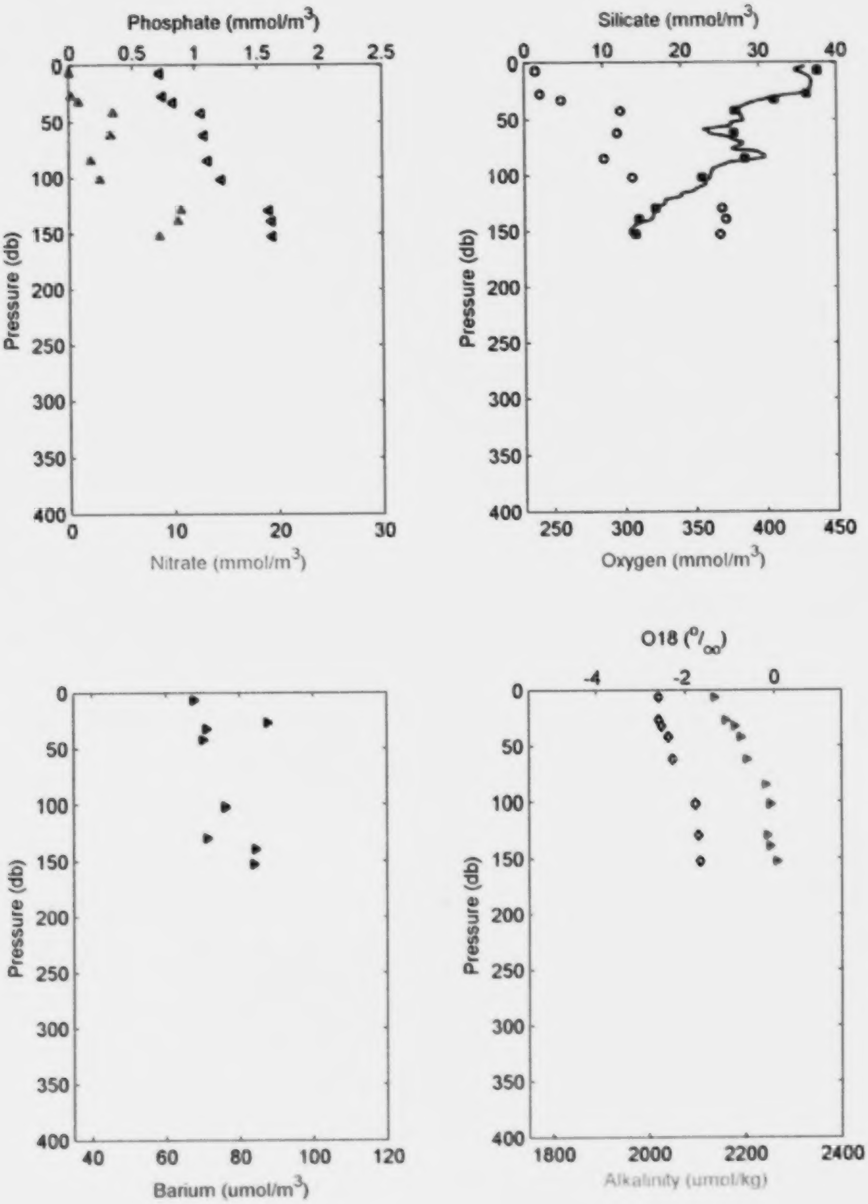




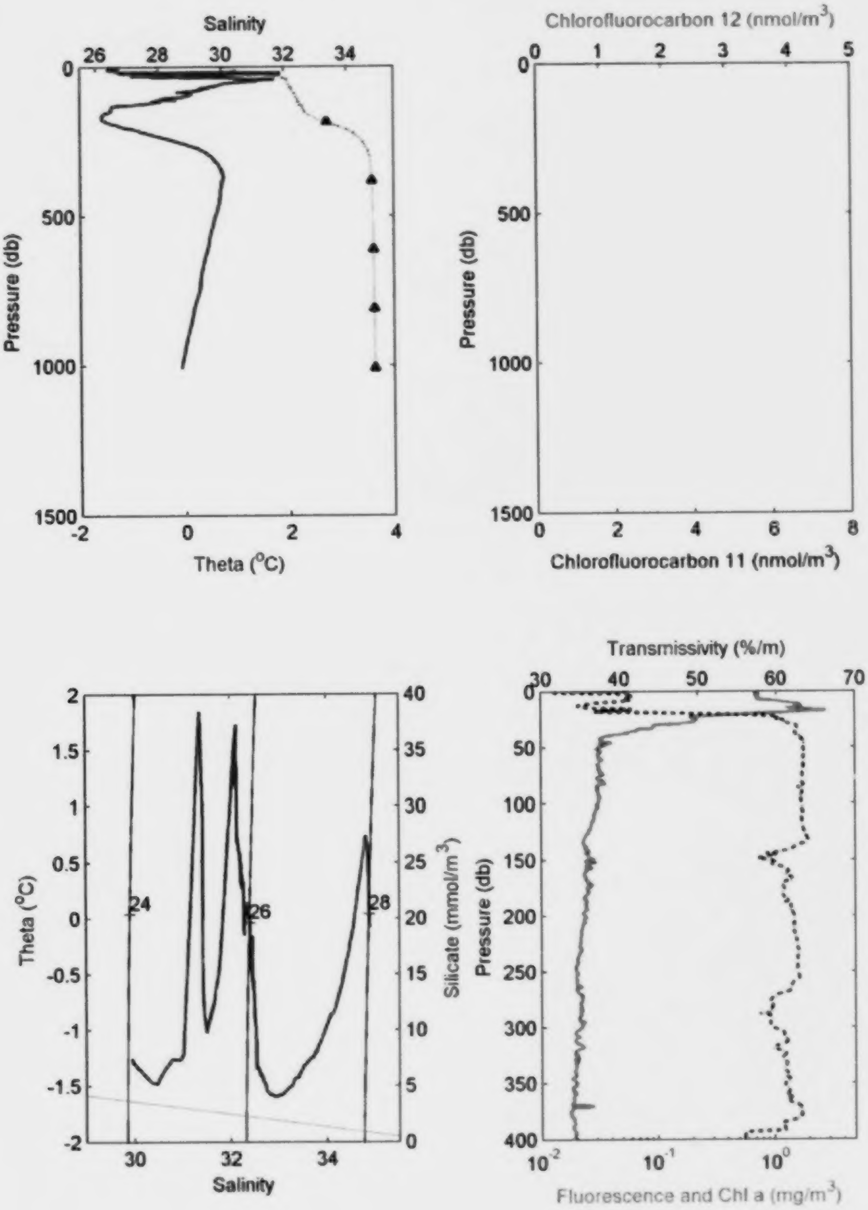




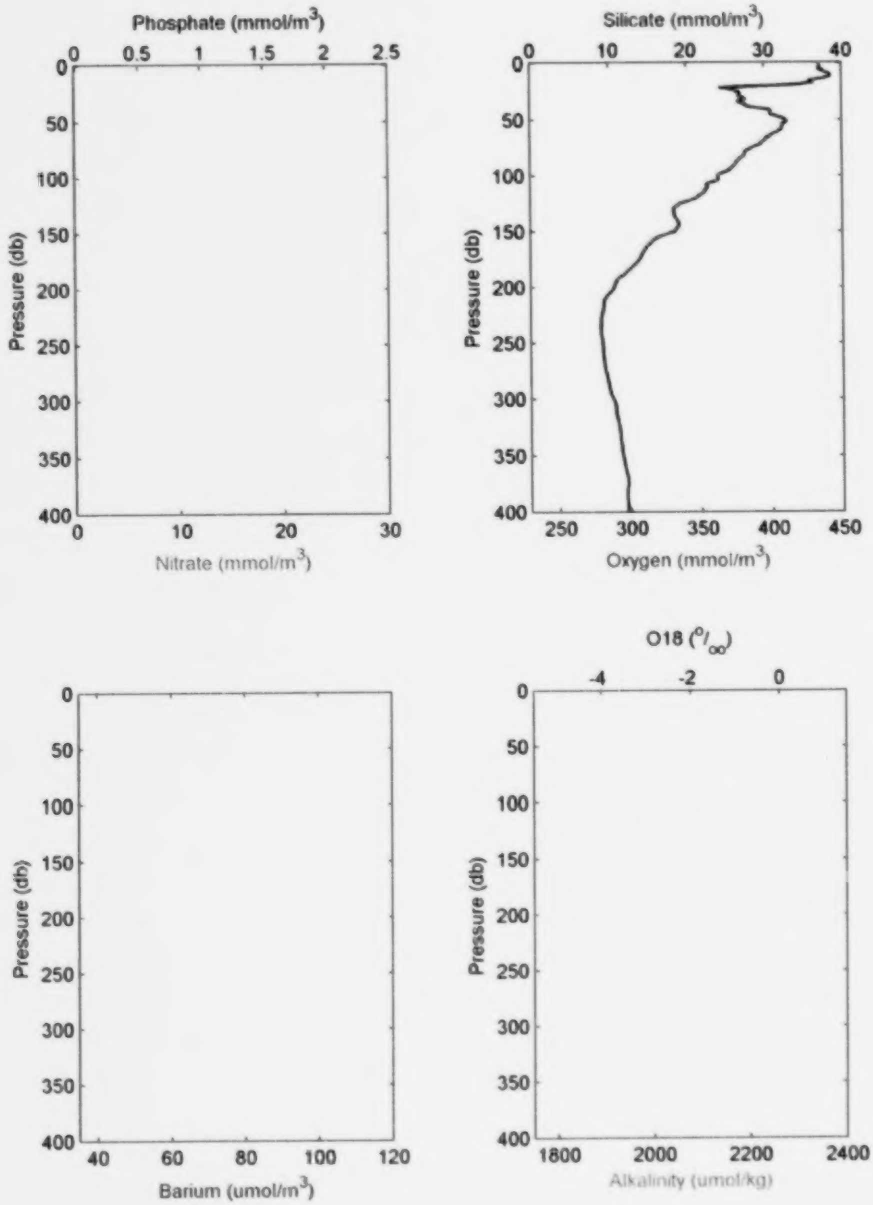
2005-04: Cast 12 Station BS3



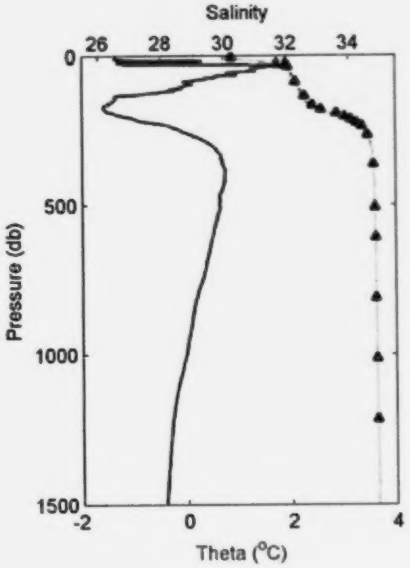
2005-04: Cast 13 Station BS3-B

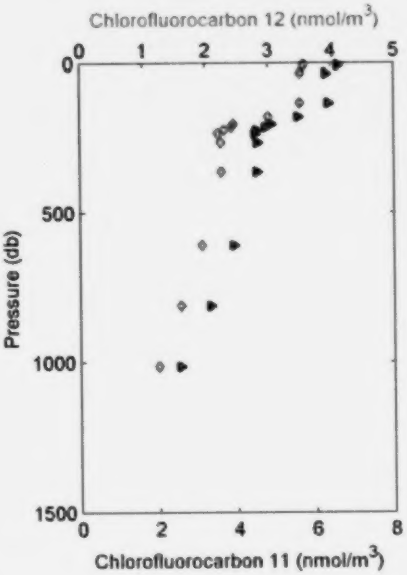


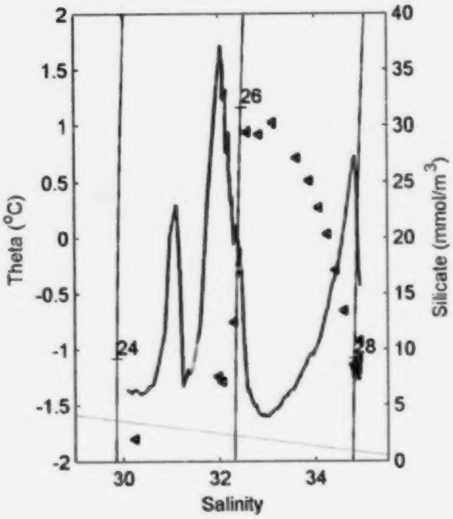
2005-04: Cast 13 Station BS3-B

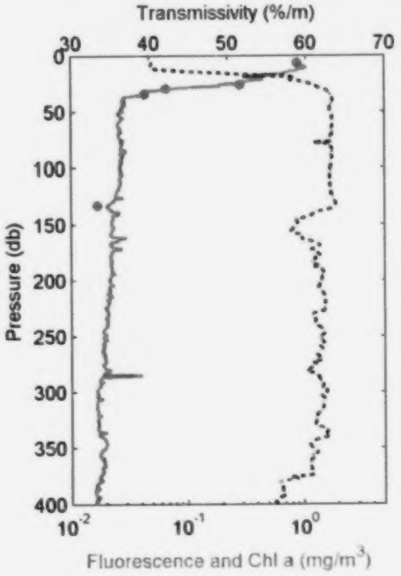


2005-04: Cast 14 Station BS3-B

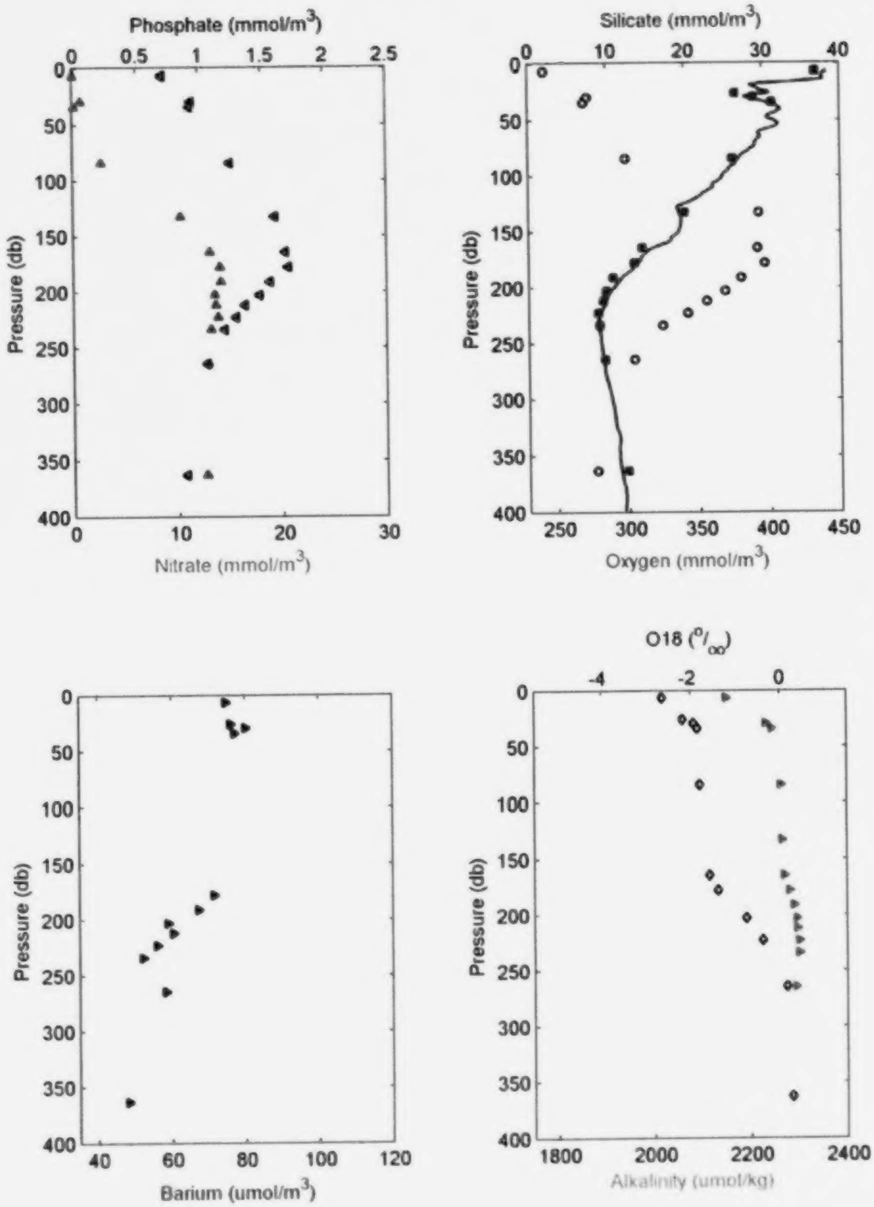




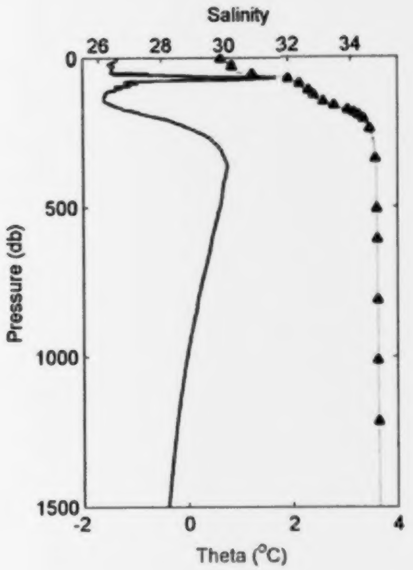


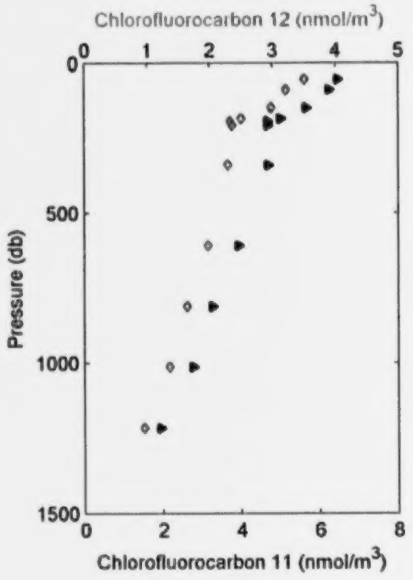


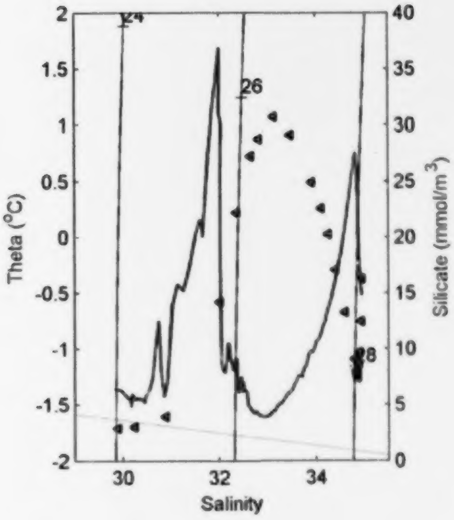
2005-04: Cast 14 Station BS3-B

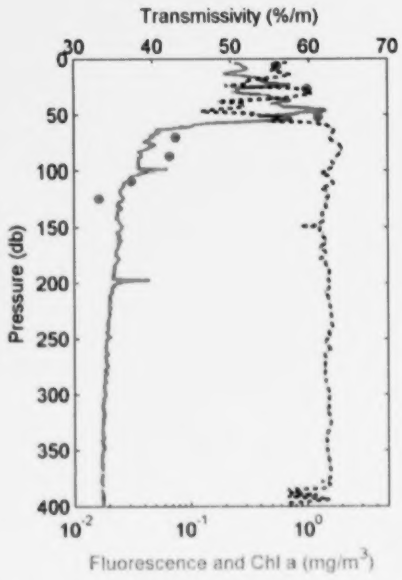


2005-04: Cast 15 Station BS3-C









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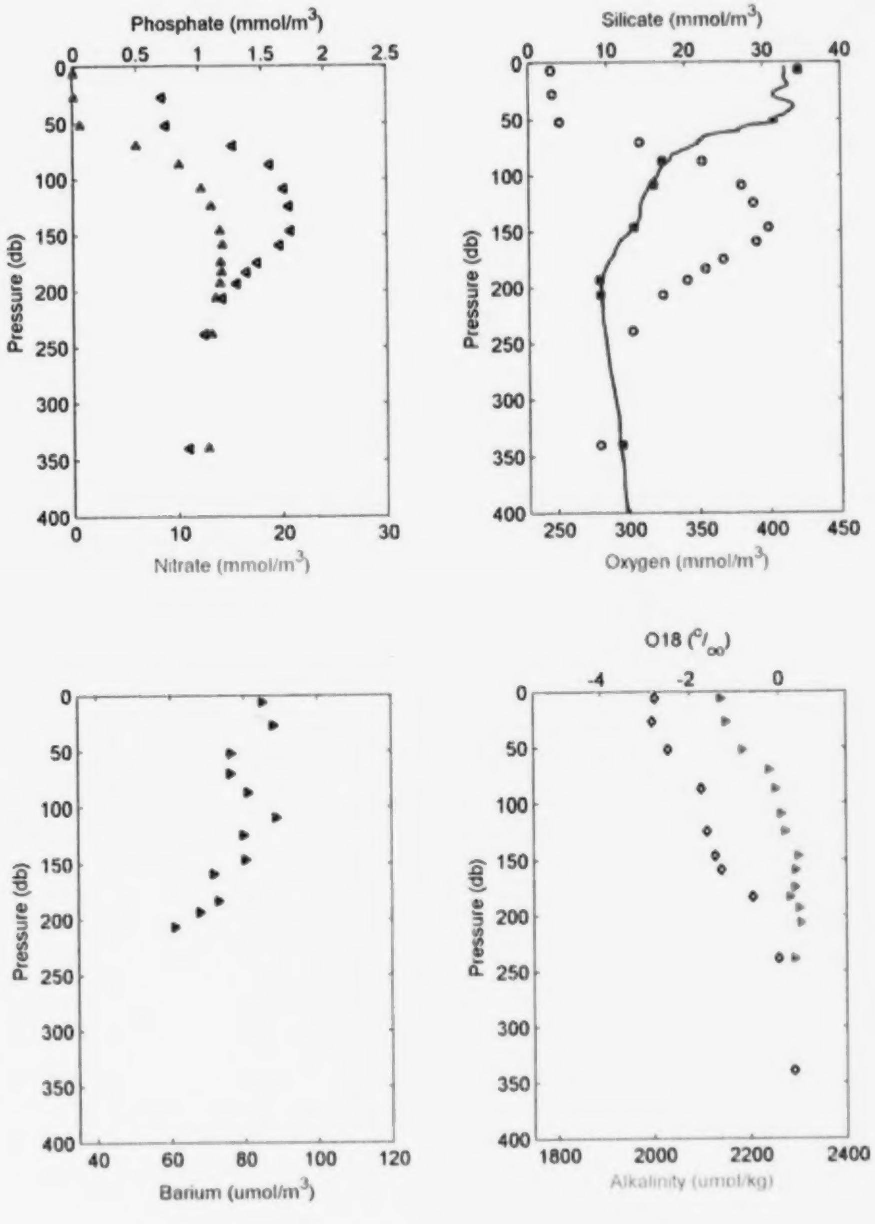
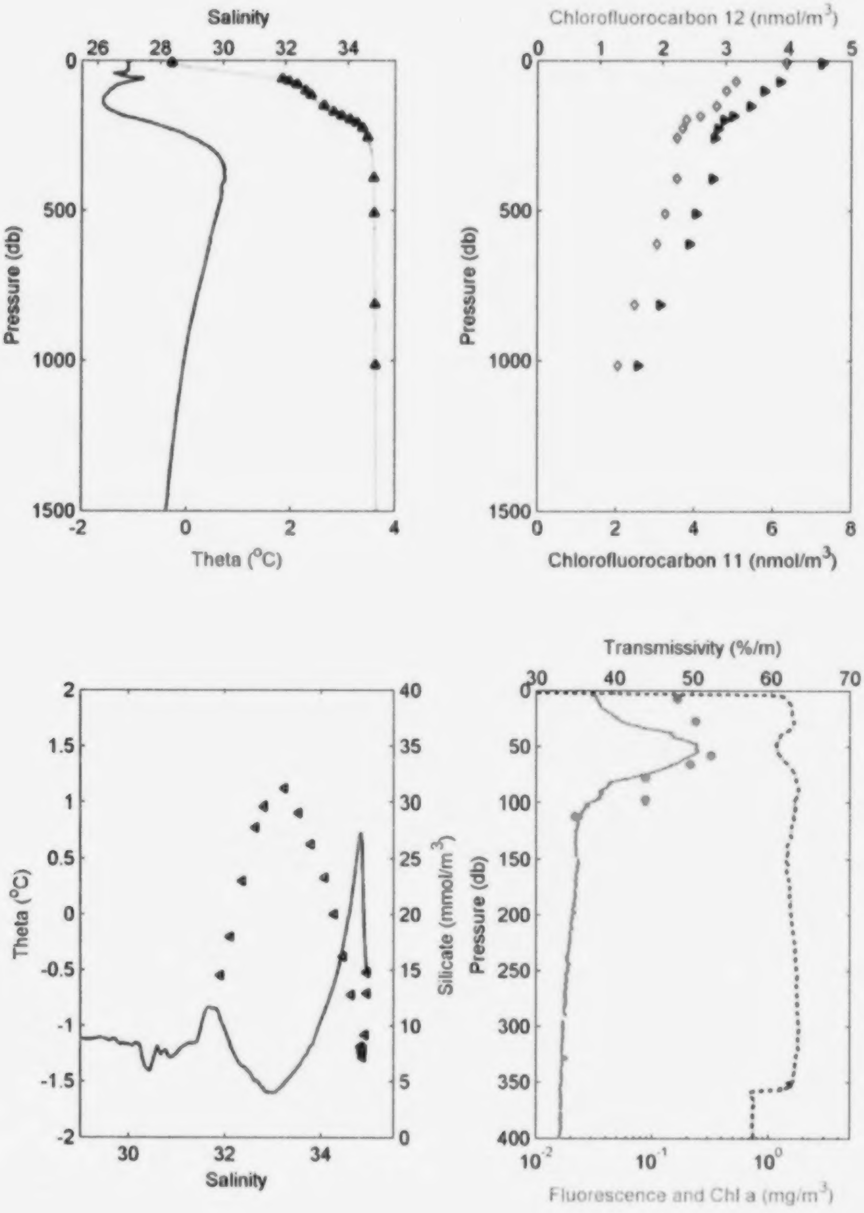
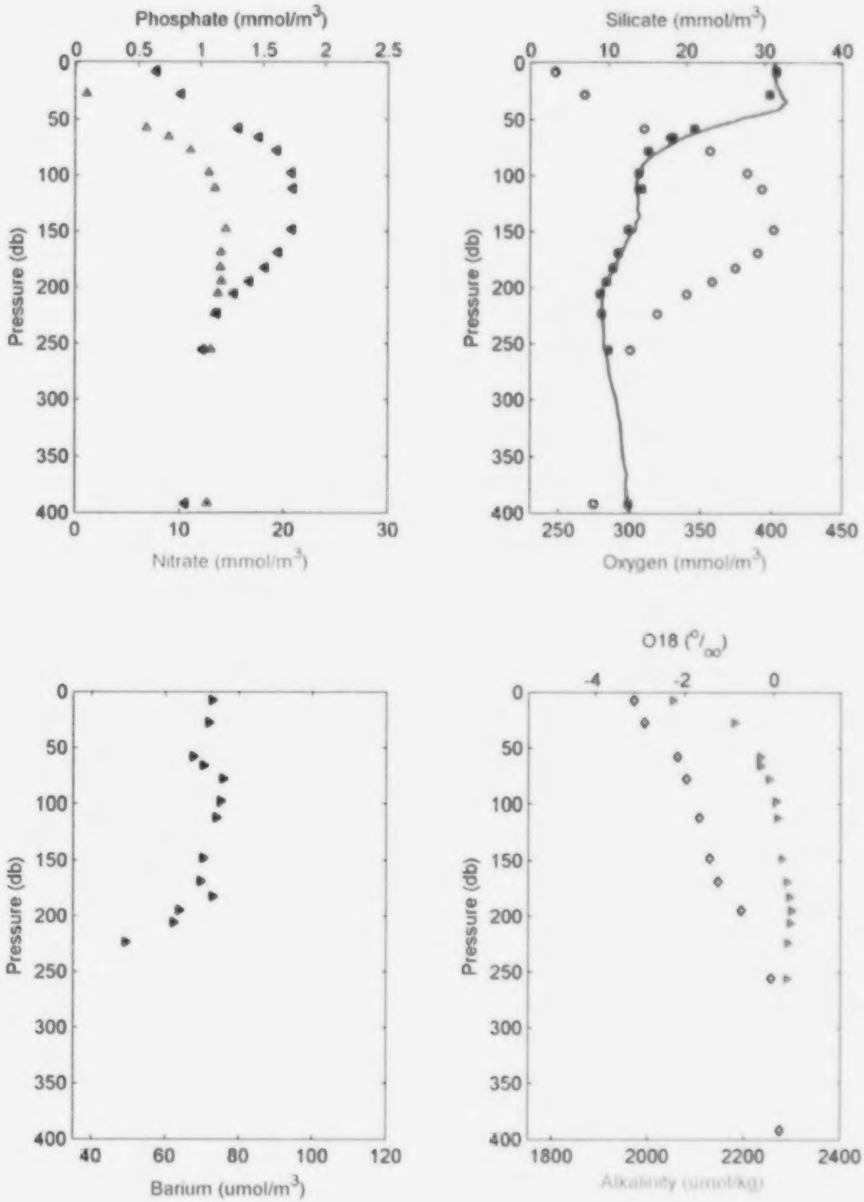


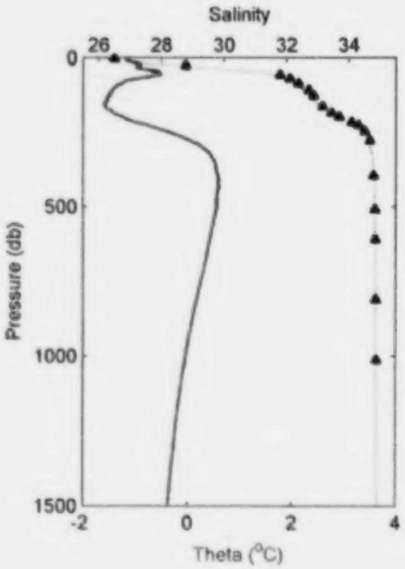
2005-04: Cast 16 Station BS3-D

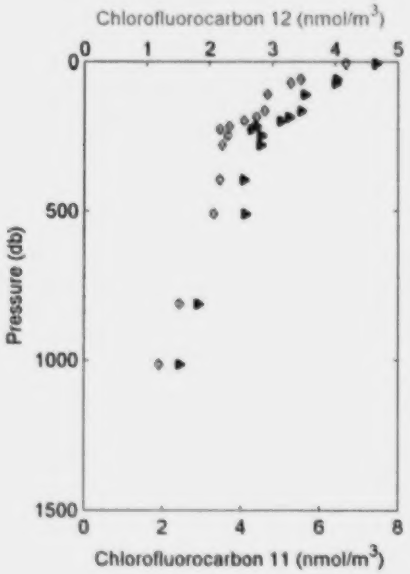


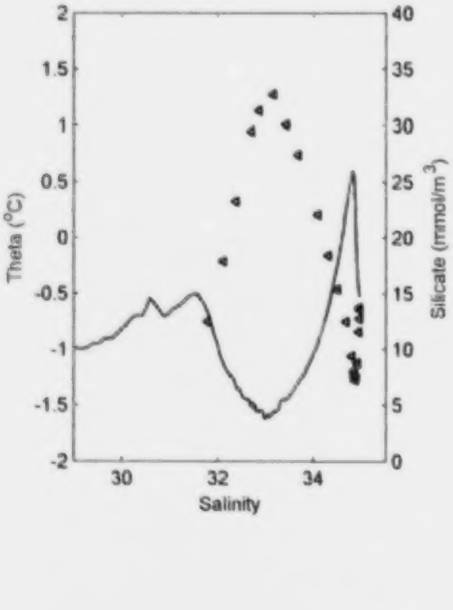
2005-04: Cast 16 Station BS3-D

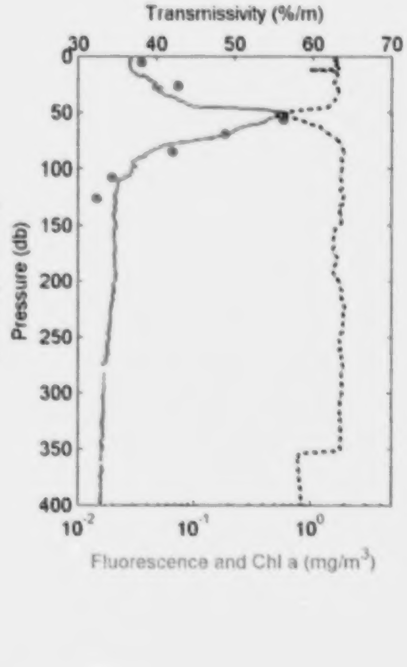


2005-04: Cast 17 Station CB2

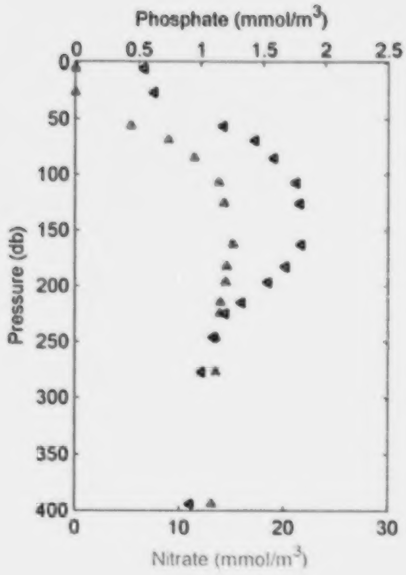


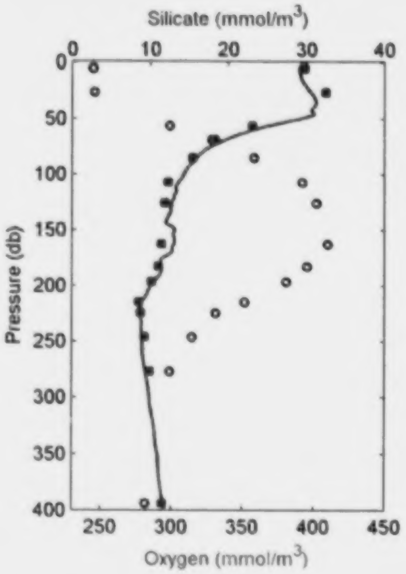


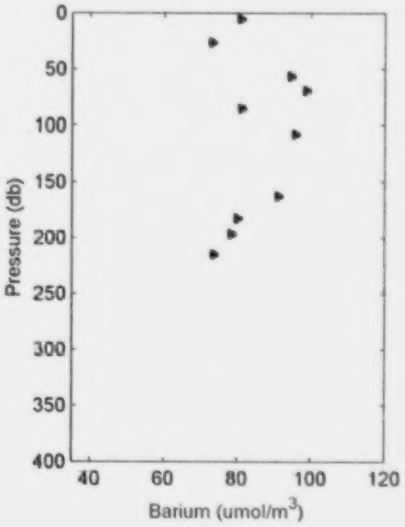


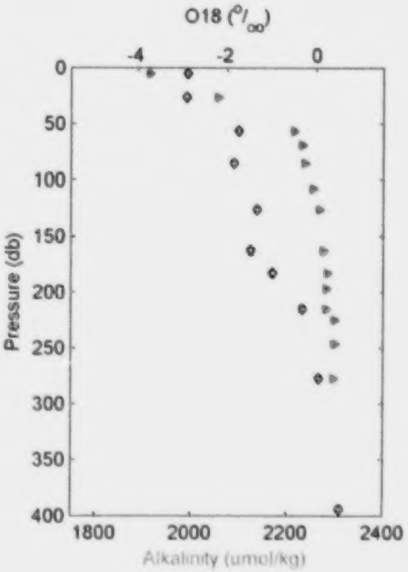


2005-04: Cast 17 Station CB2

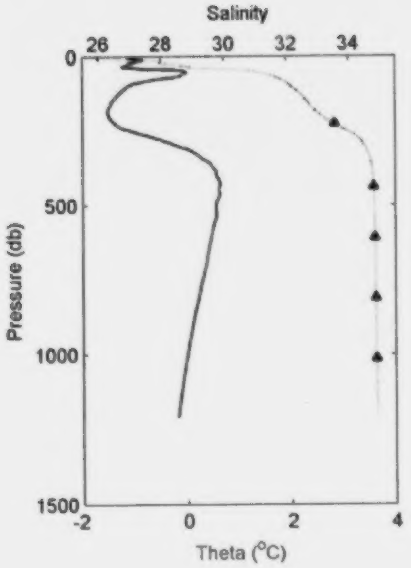


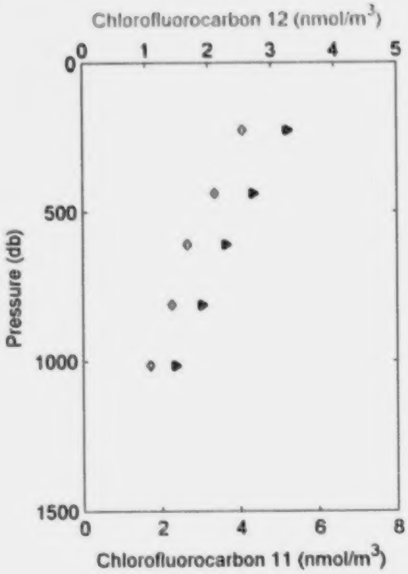


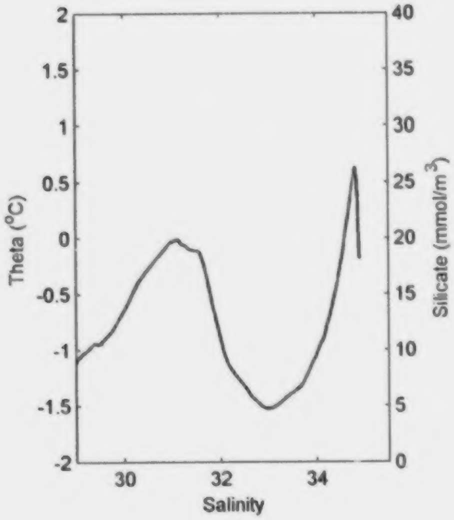


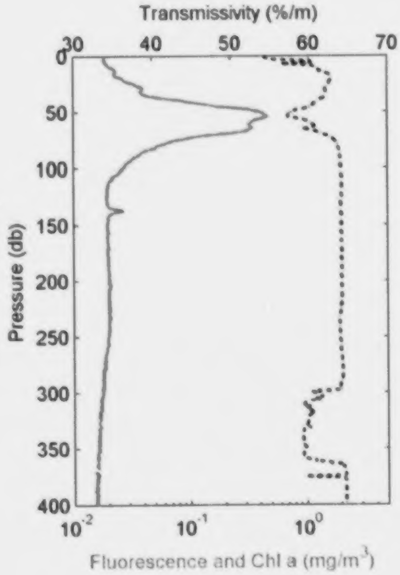


2005-04: Cast 18 Station CB3









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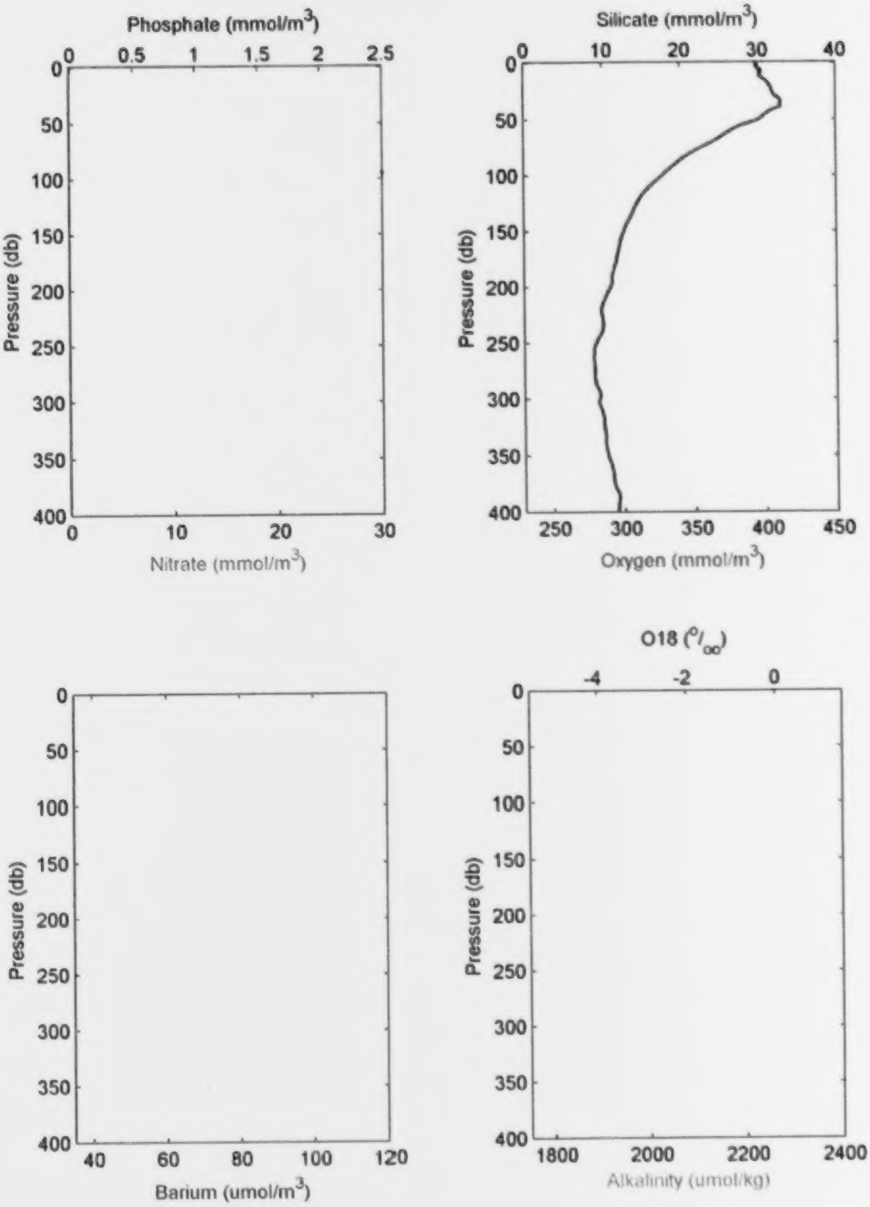
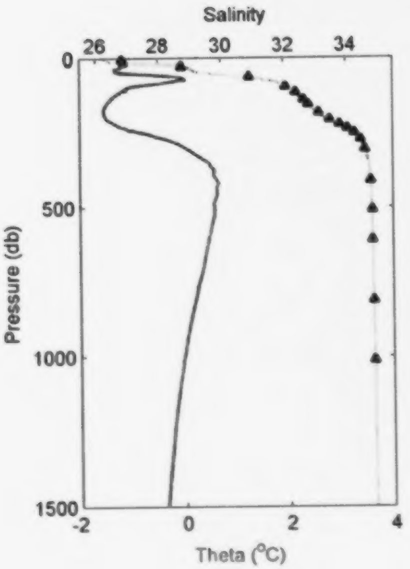
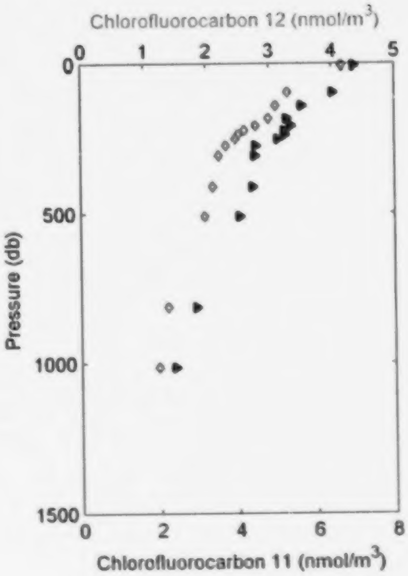
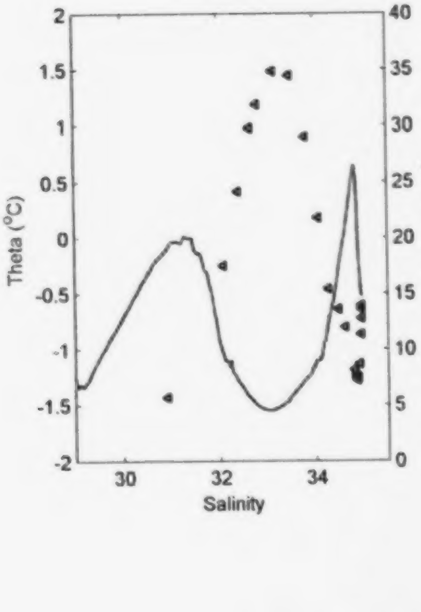
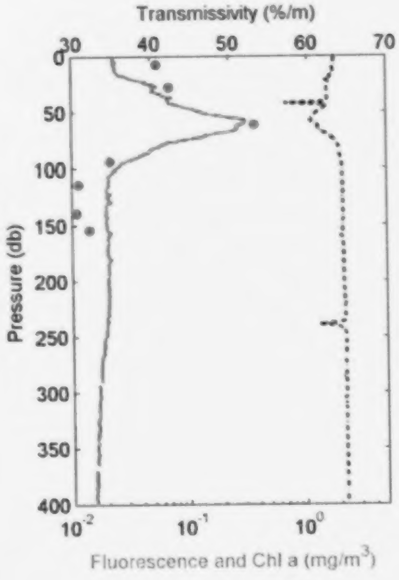


2005-04: Cast 19 Station CB3

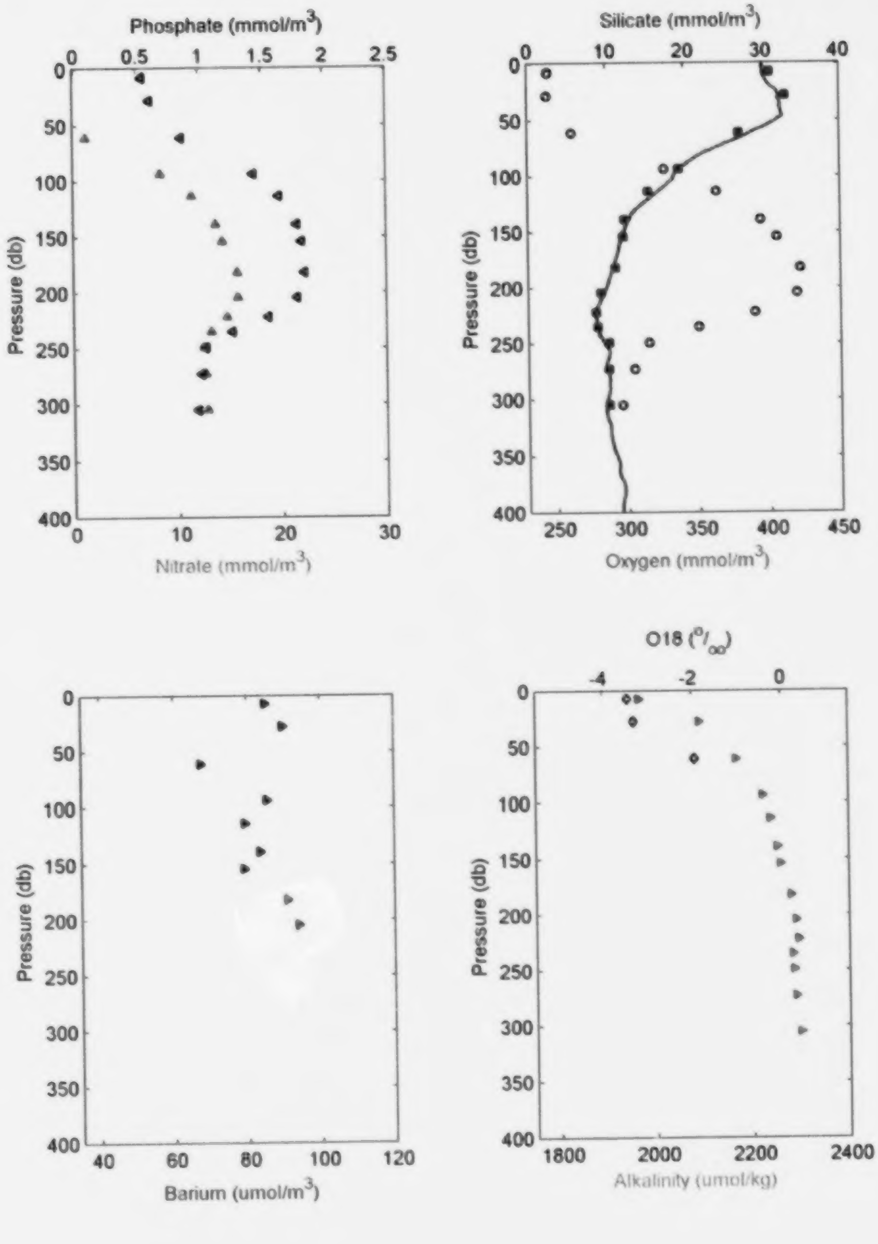




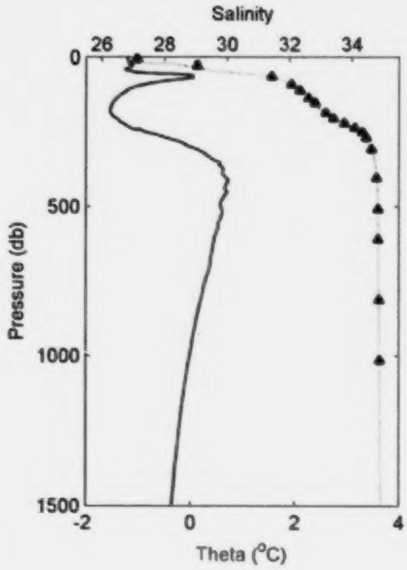


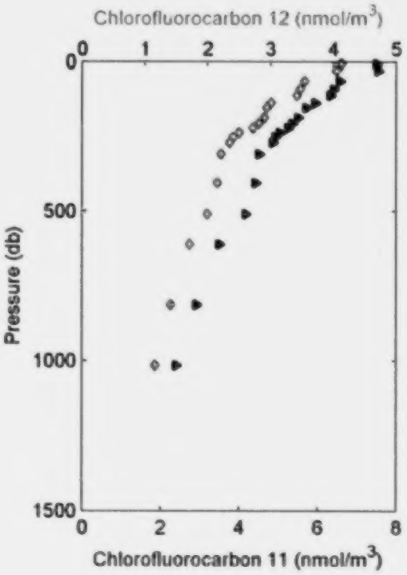


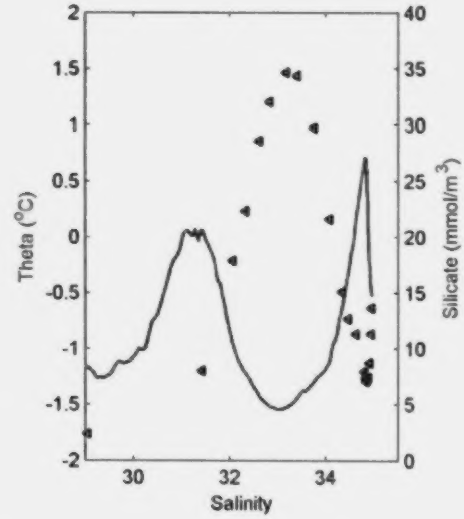
2005-04: Cast 19 Station CB3

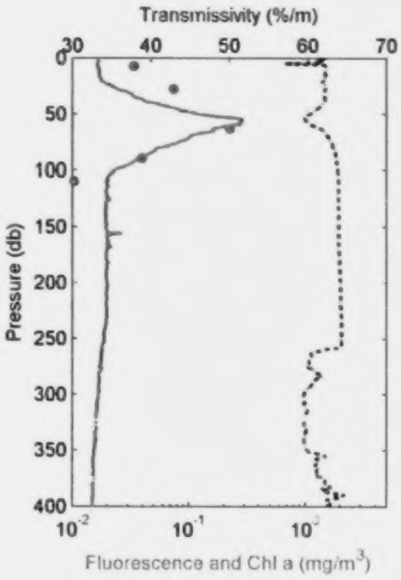


2005-04: Cast 20 Station CB4

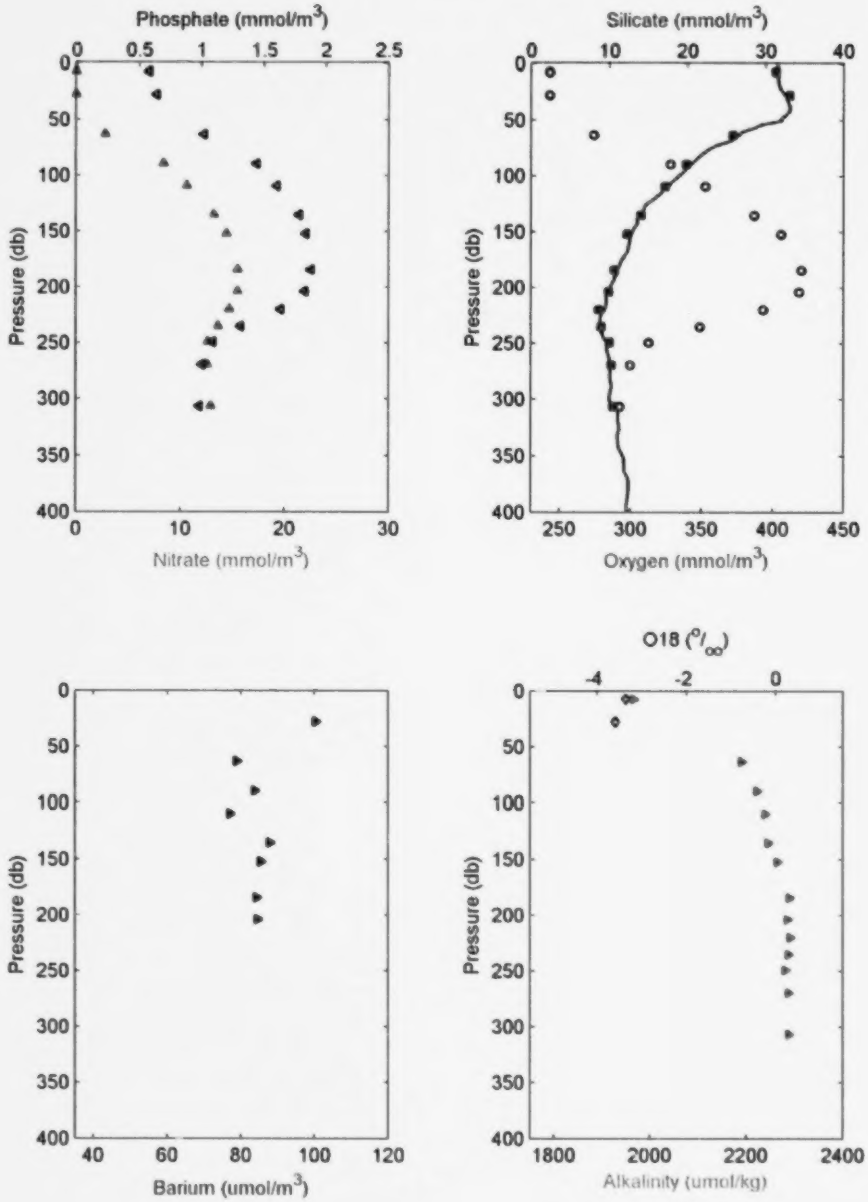




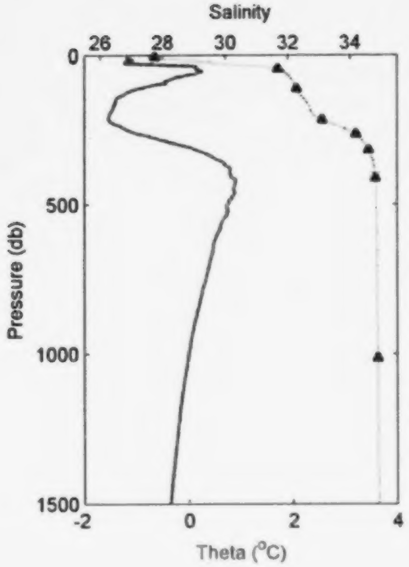


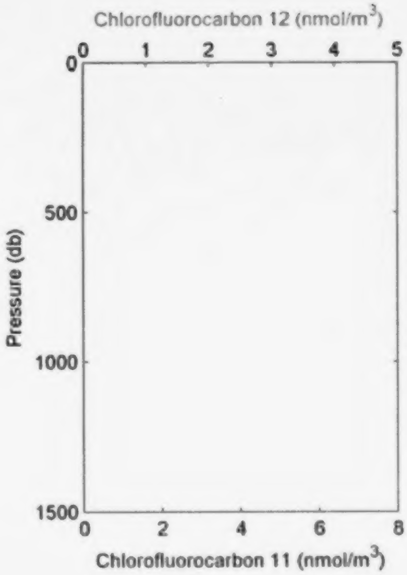


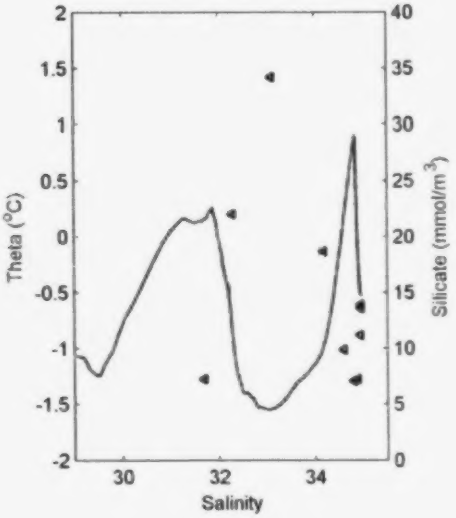
2005-04: Cast 20 Station CB4

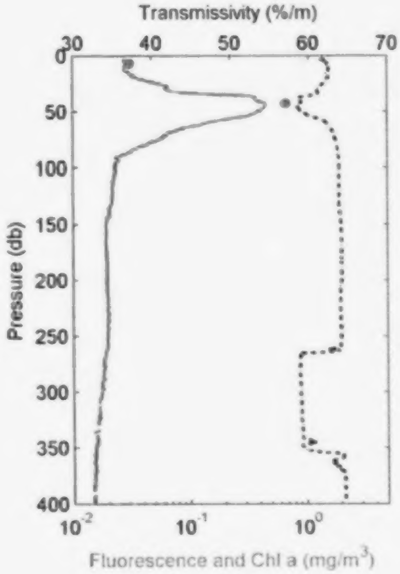


2005-04: Cast 21 Station CB5

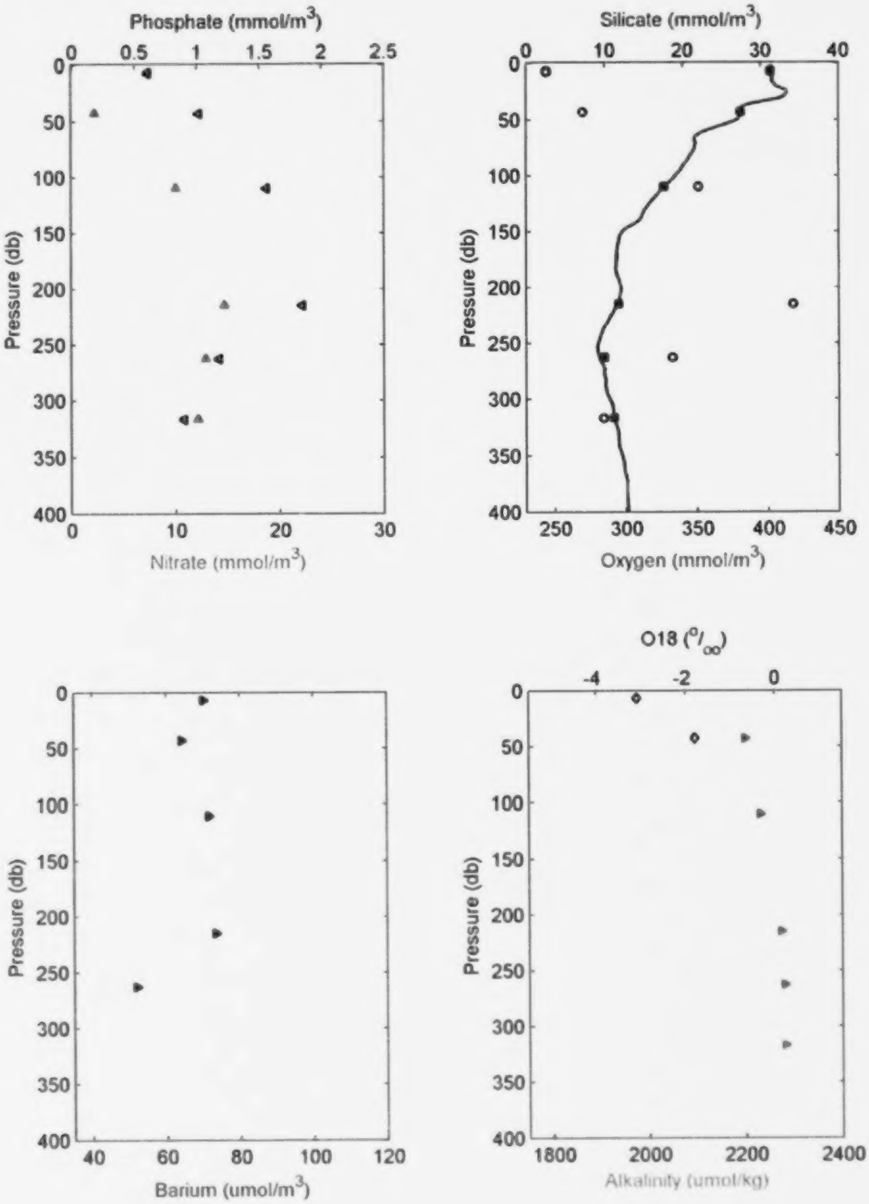




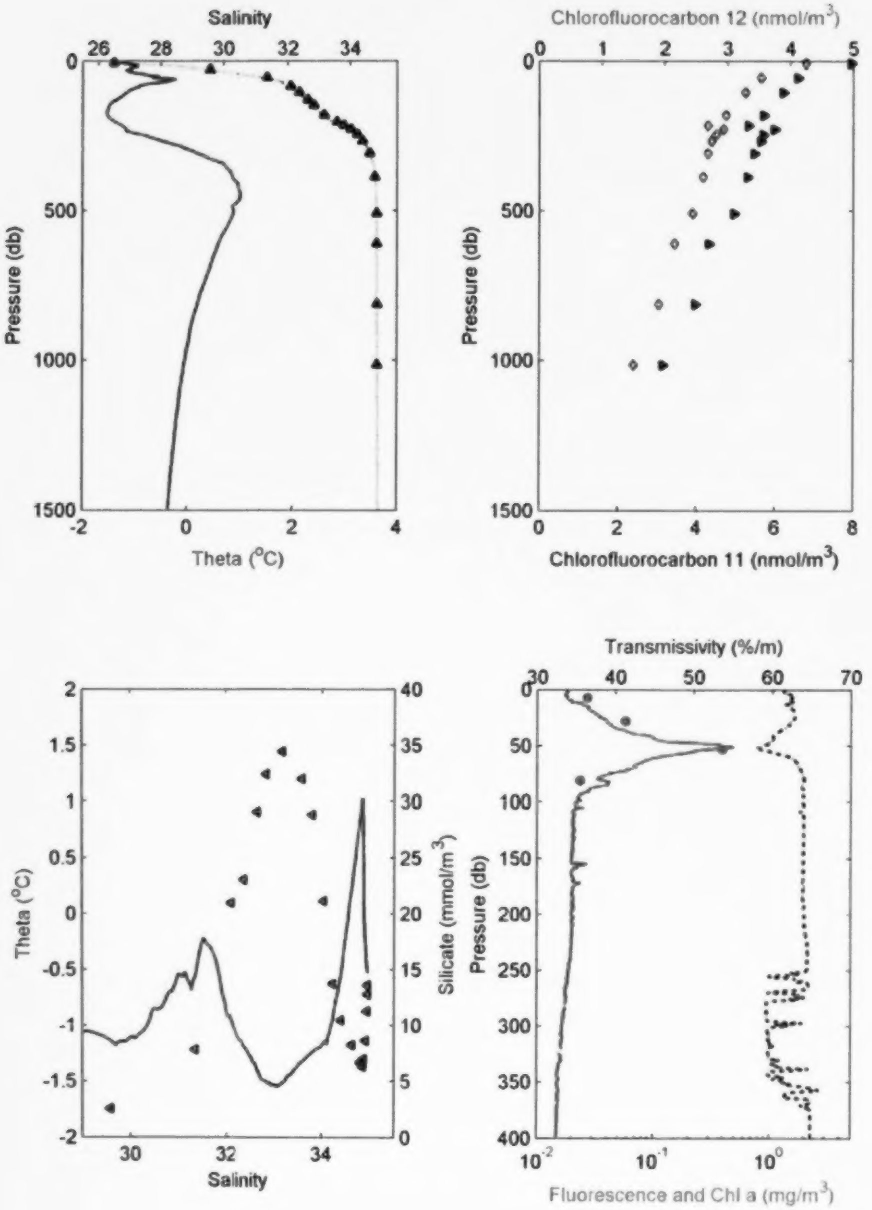




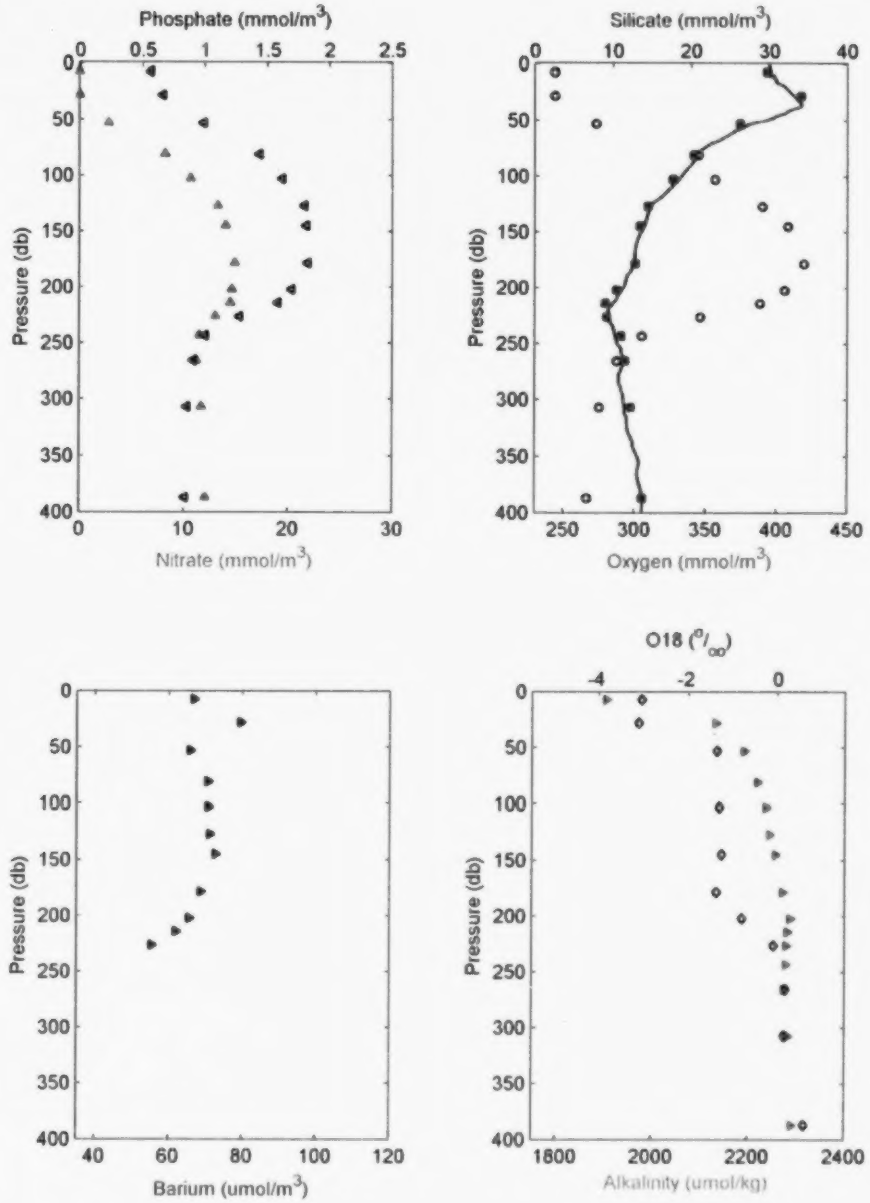
2005-04: Cast 21 Station CB5



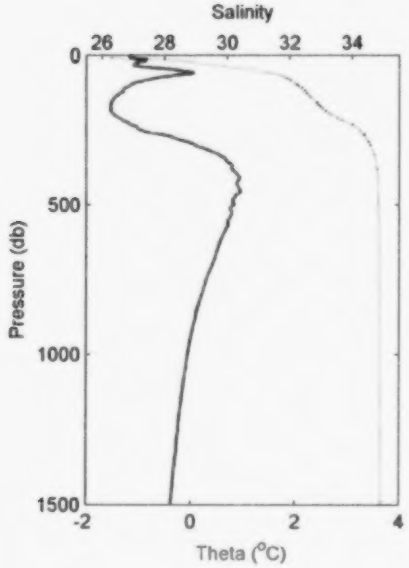
2005-04: Cast 22 Station CB5A

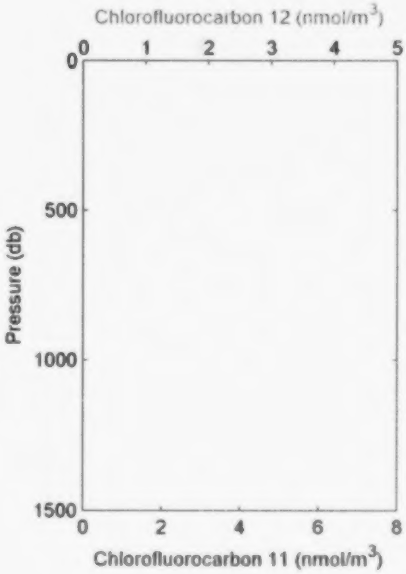


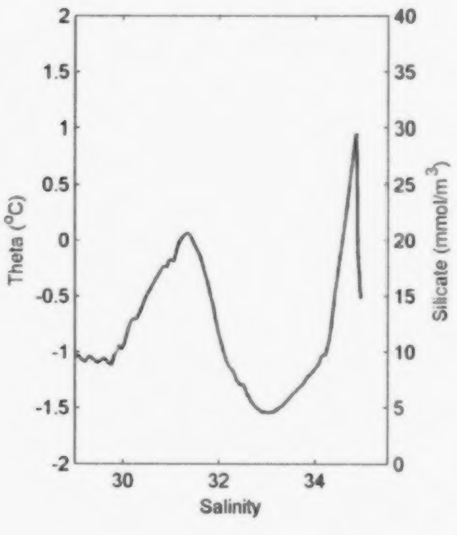
2005-04: Cast 22 Station CB5A

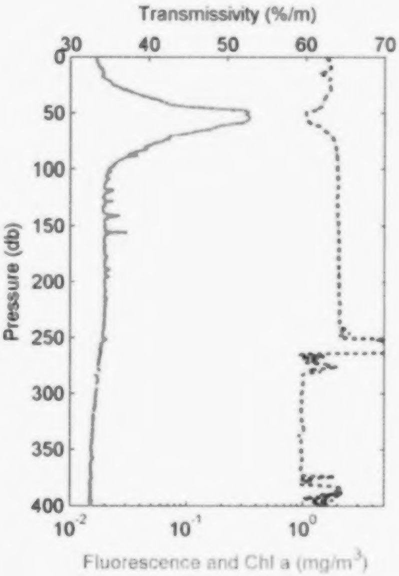


2005-04: Cast 23 Station CB5B

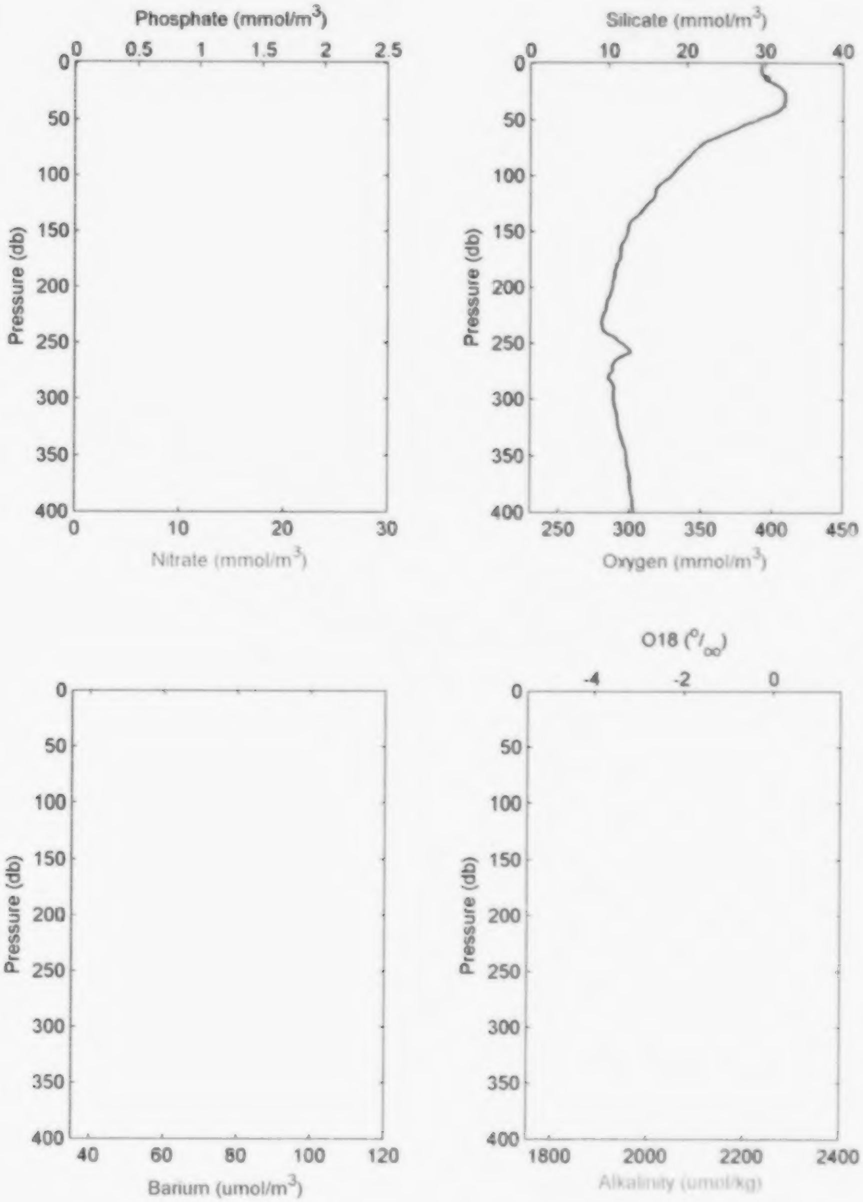




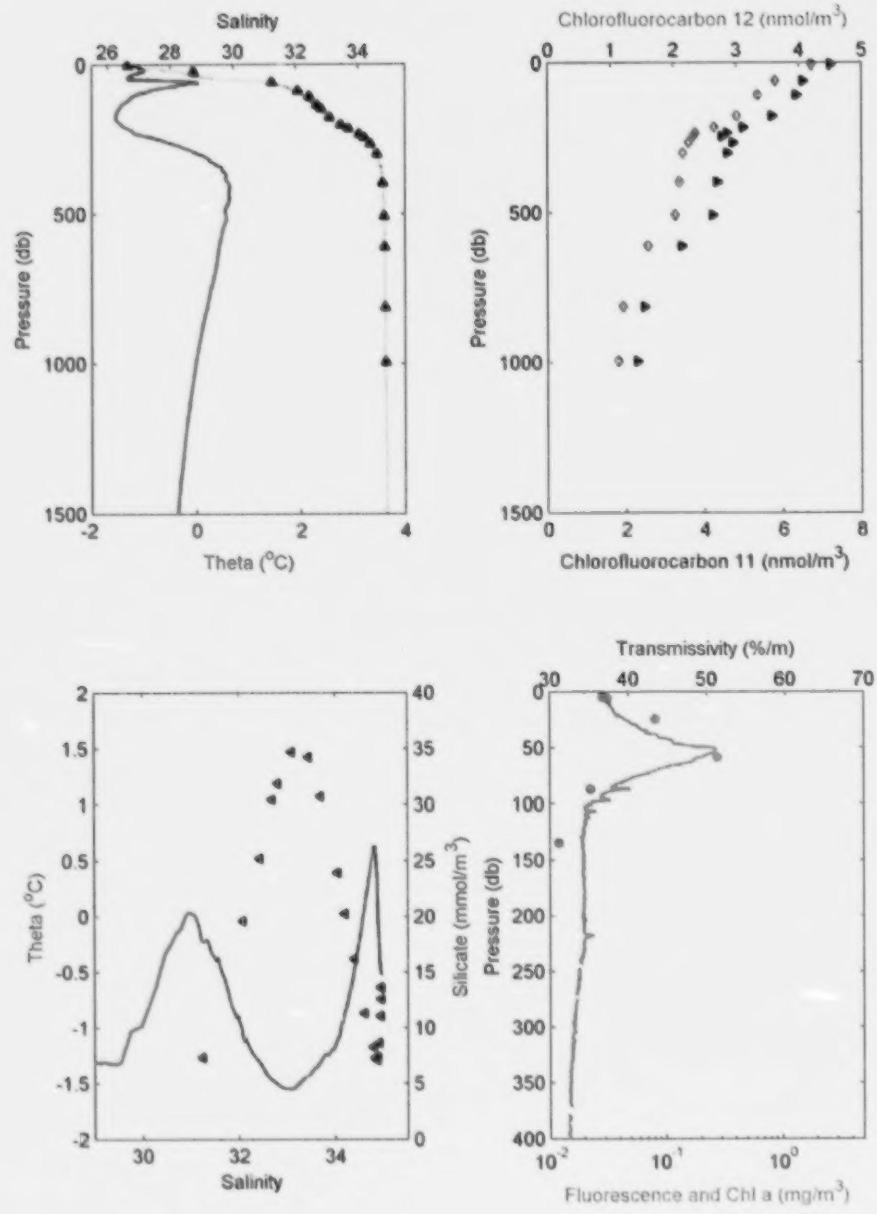




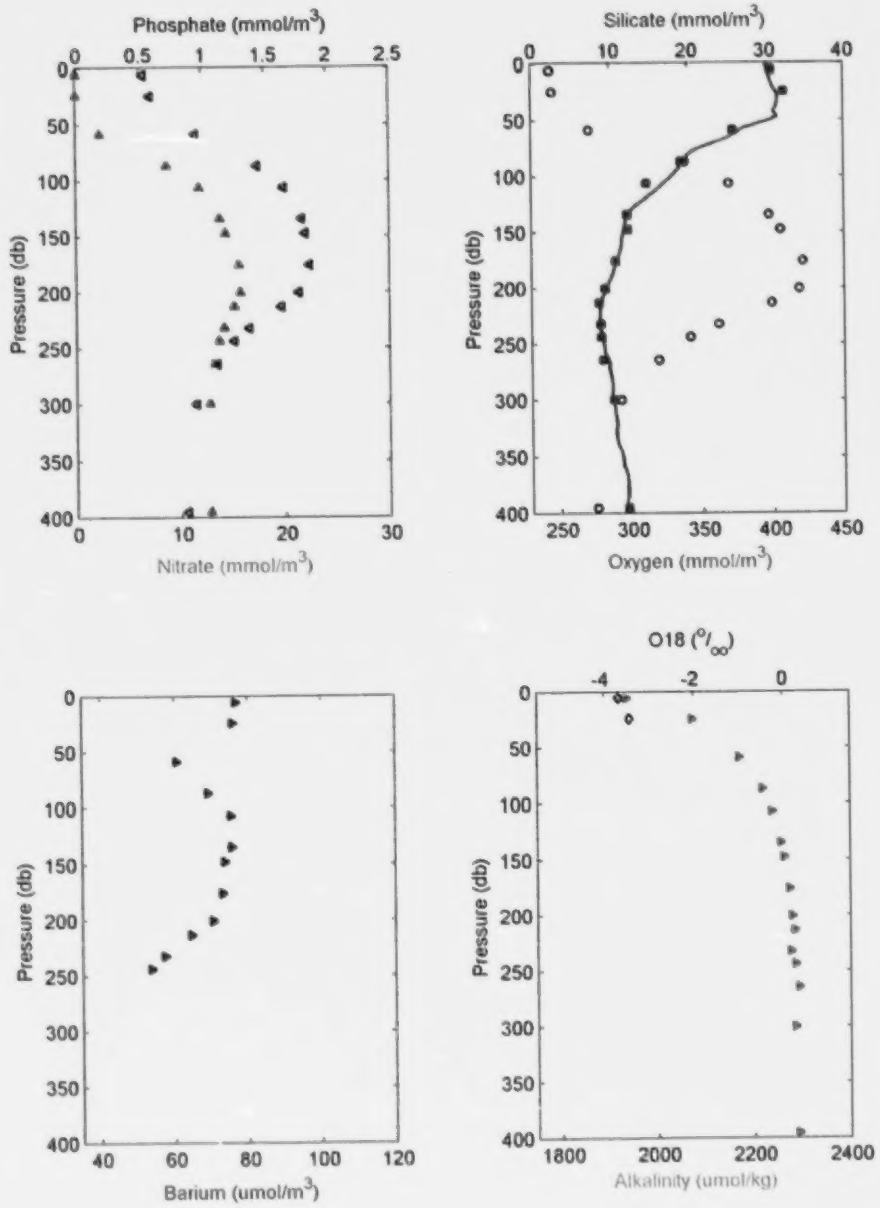
2005-04: Cast 23 Station CB5B



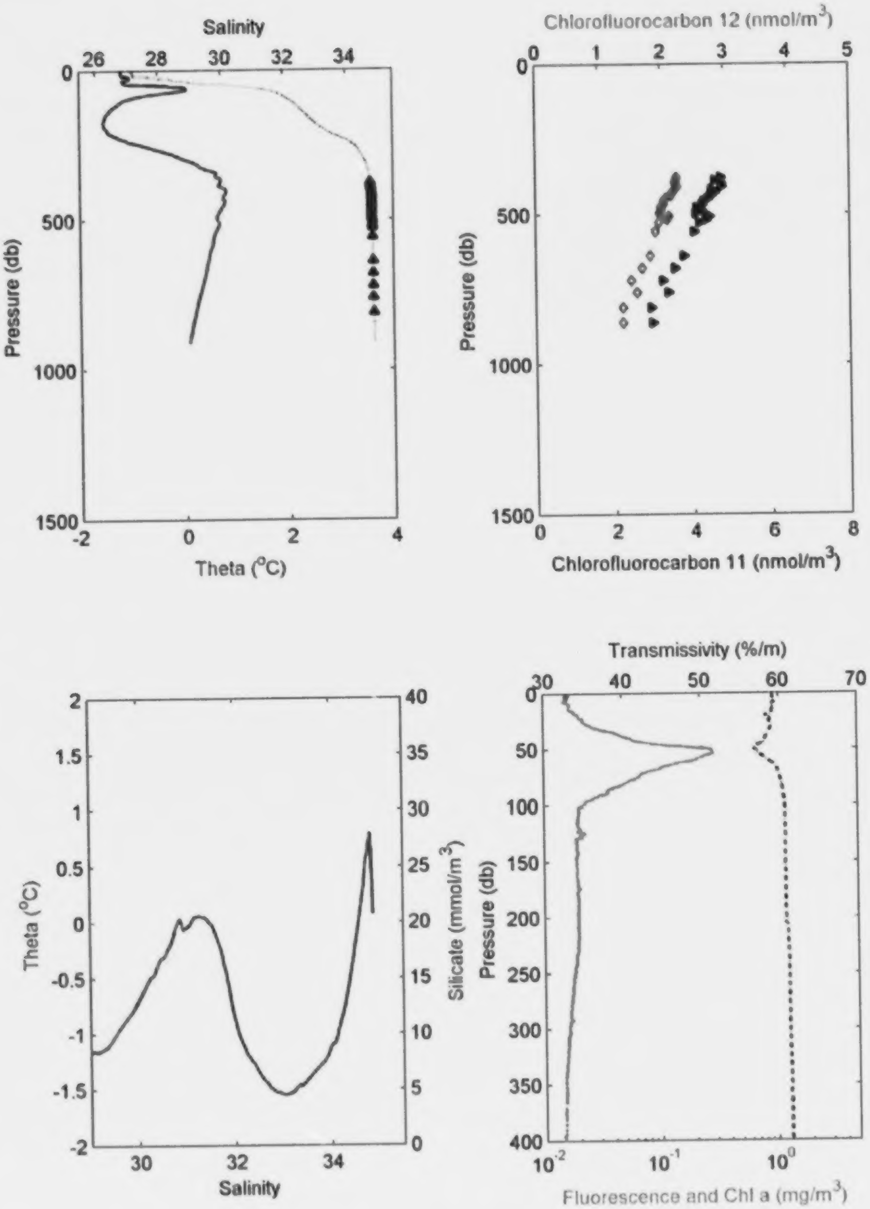
2005-04: Cast 24 Station CB6



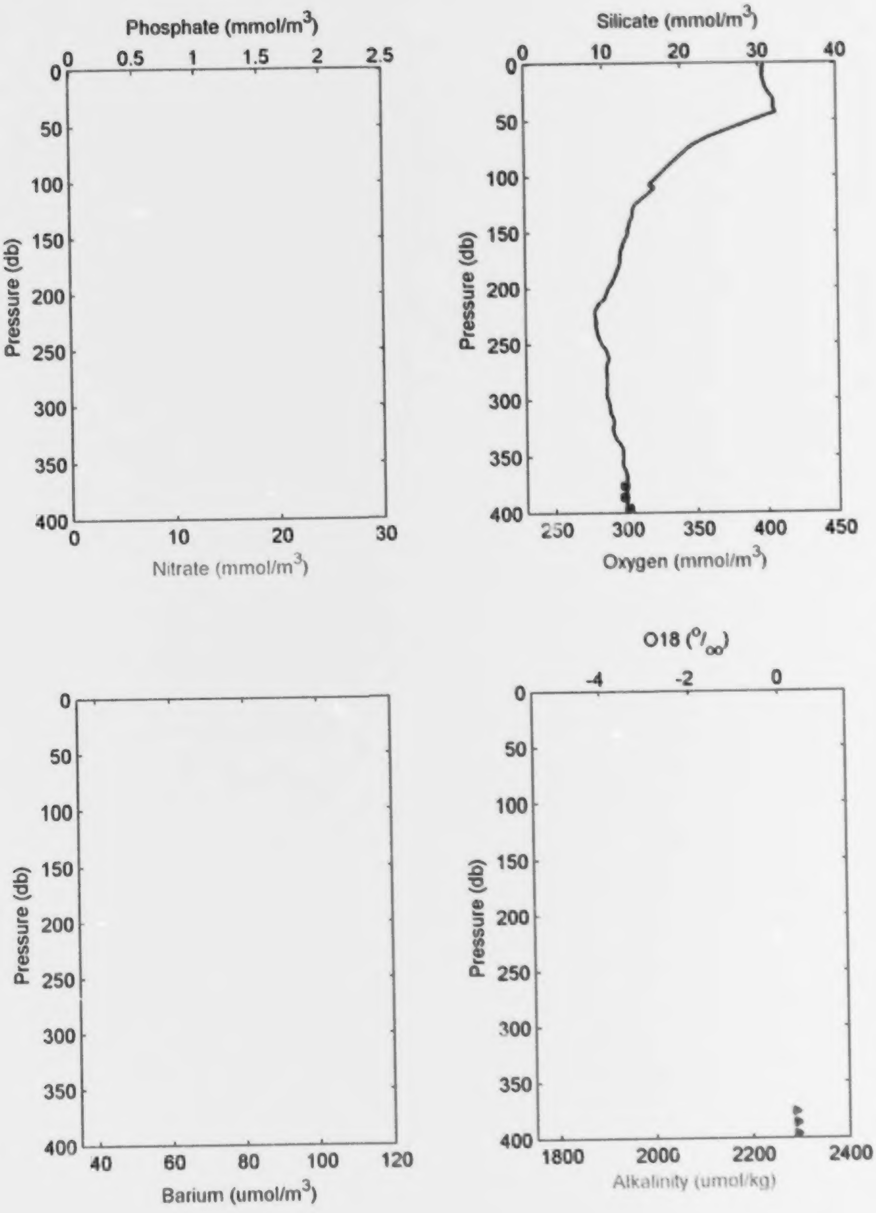
2005-04: Cast 24 Station CB6



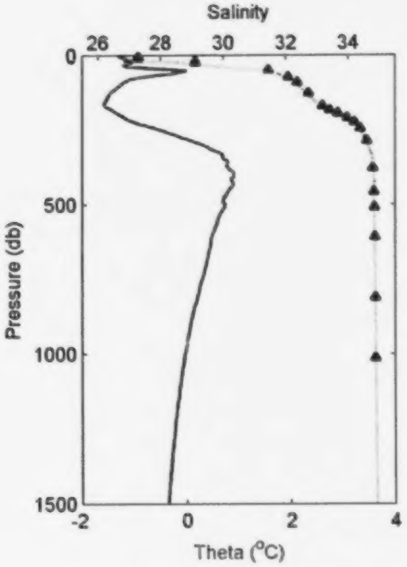
2005-04: Cast 25 Station CB4

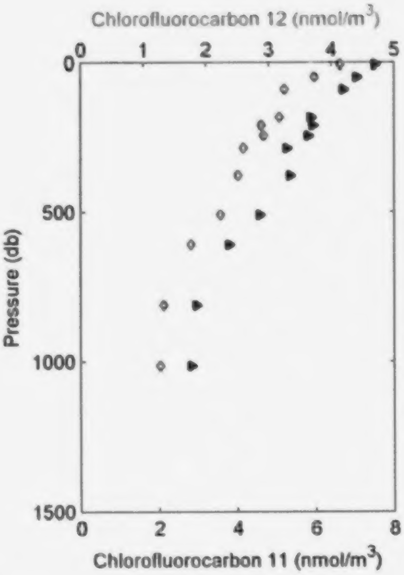


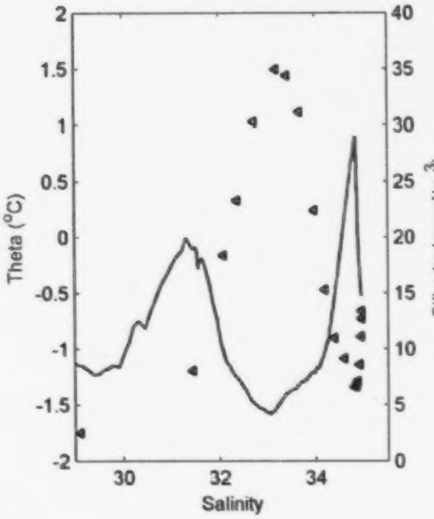
2005-04: Cast 25 Station CB4

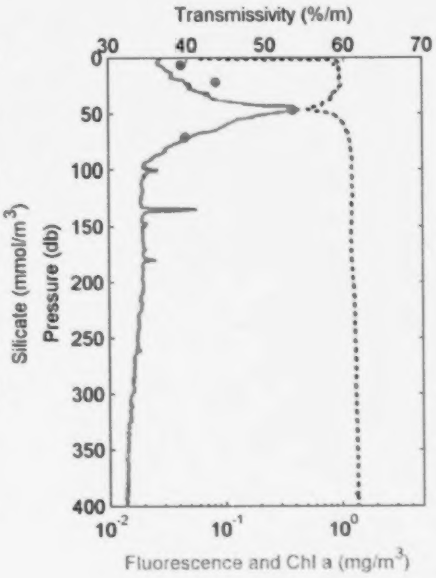


2005-04: Cast 26 Station CB7

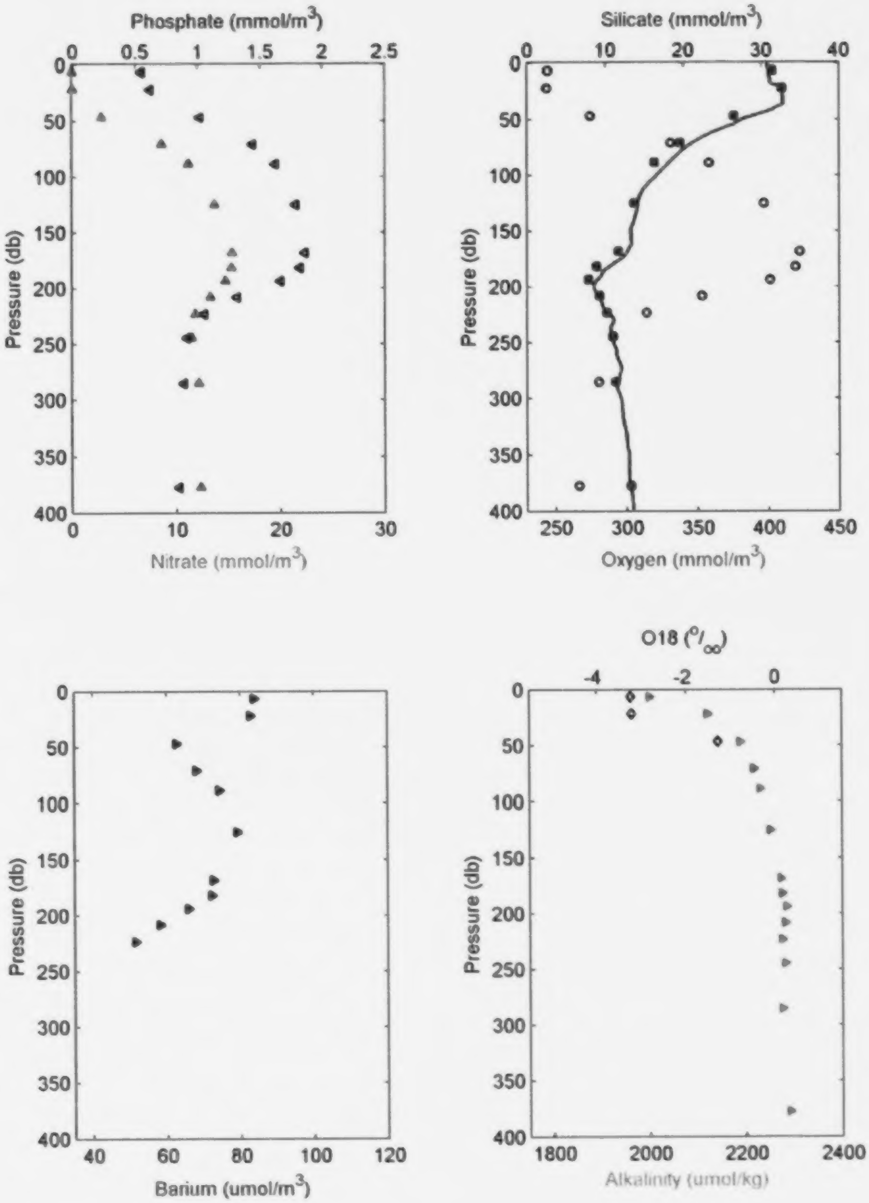




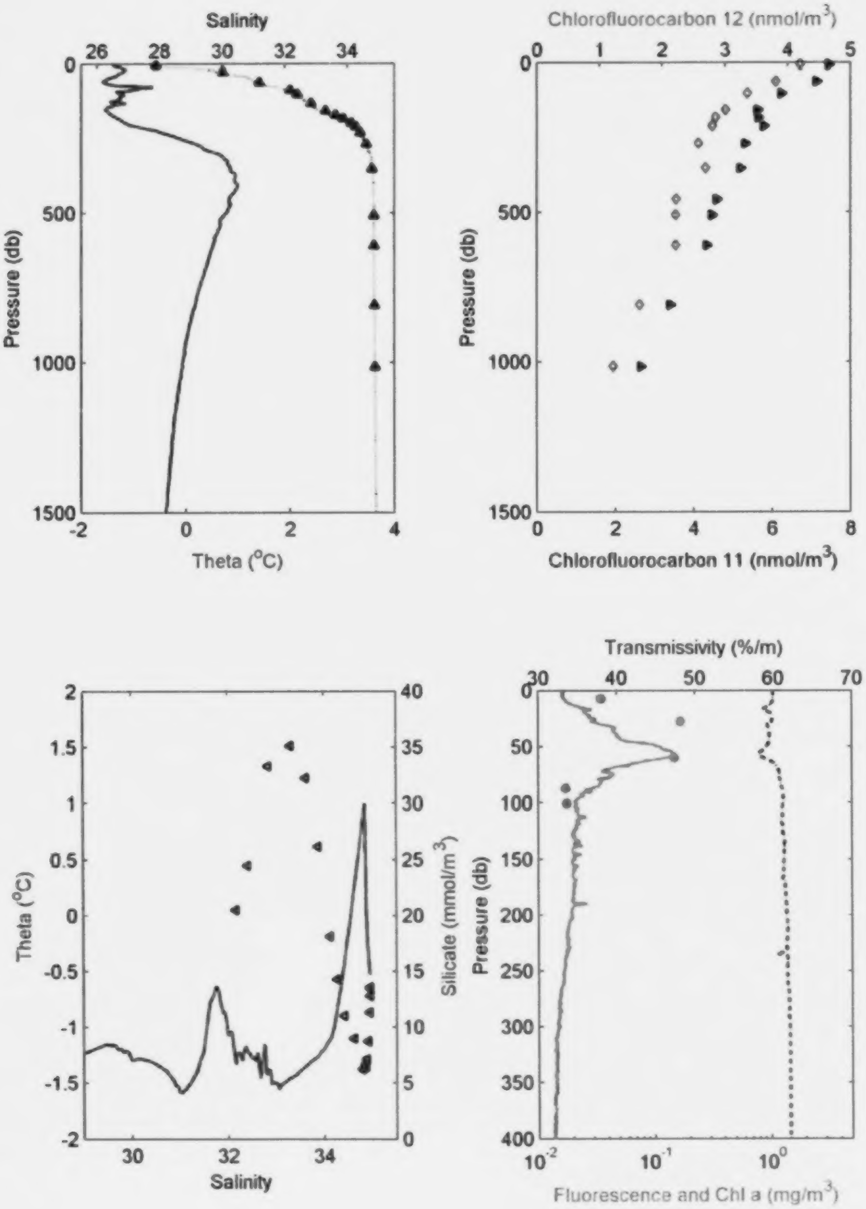




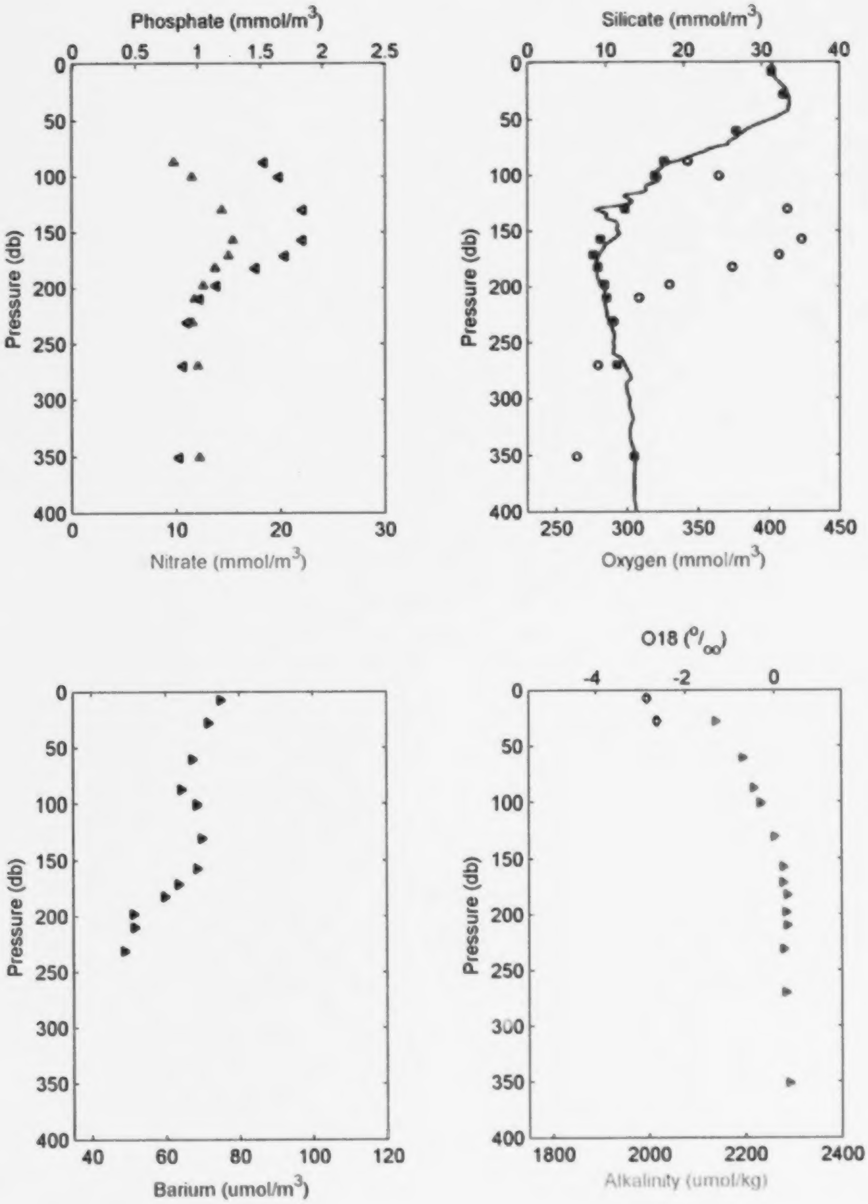
2005-04: Cast 26 Station CB7



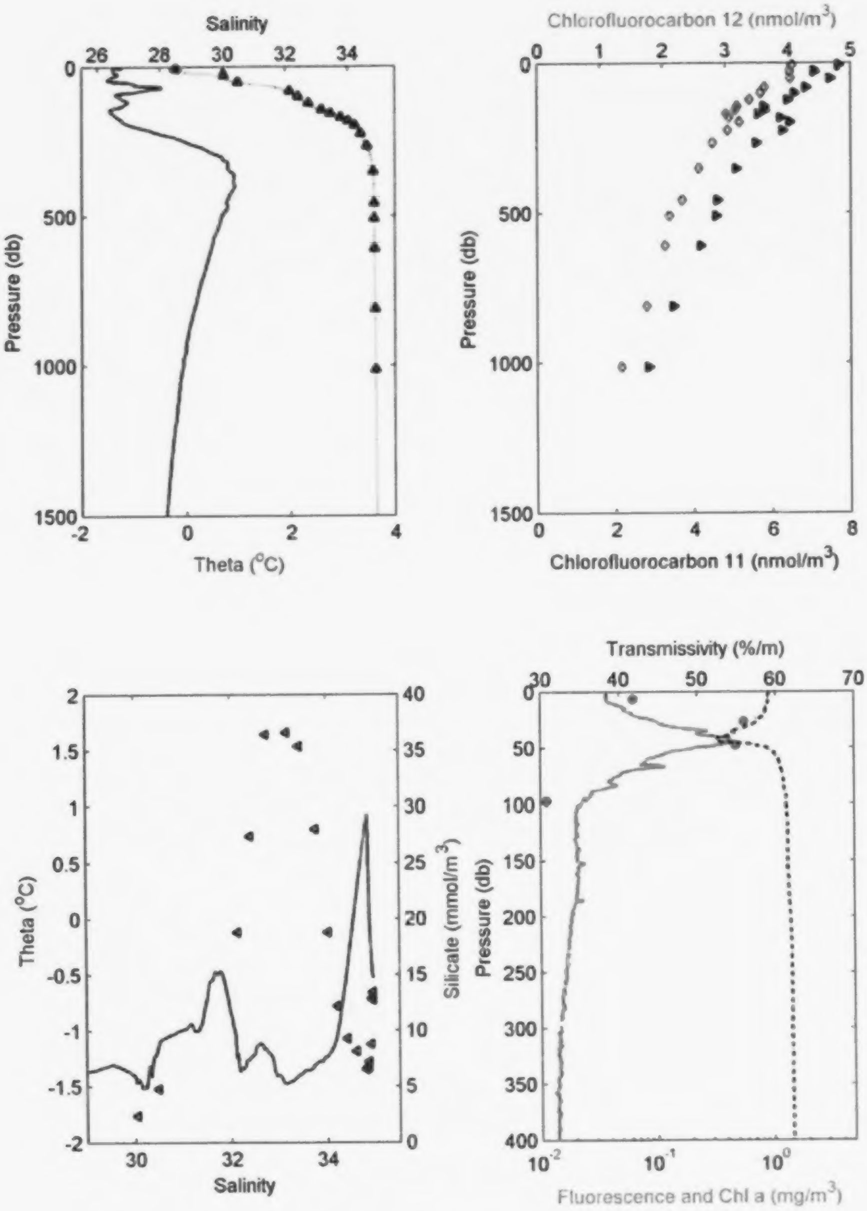
2005-04: Cast 27 Station CB8



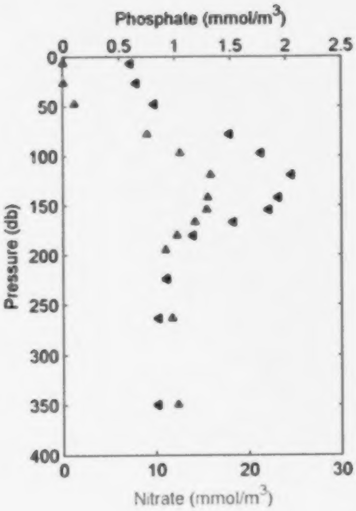
2005-04: Cast 27 Station CB8

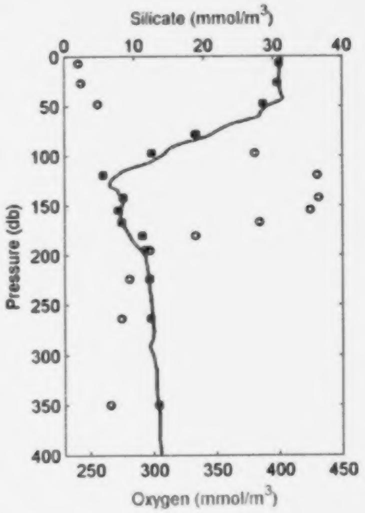


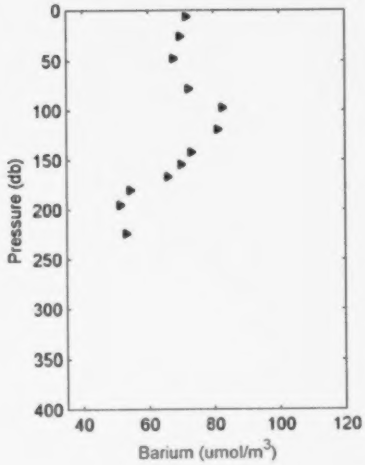
2005-04: Cast 28 Station CB9

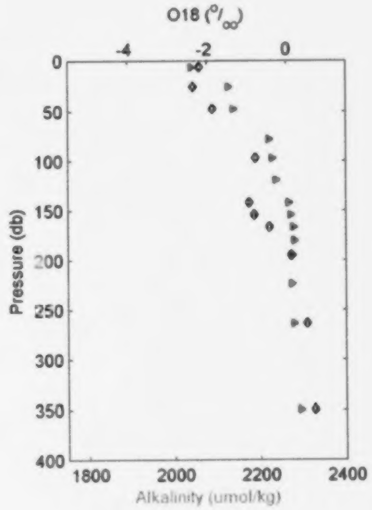


2005-04: Cast 28 Station CB9

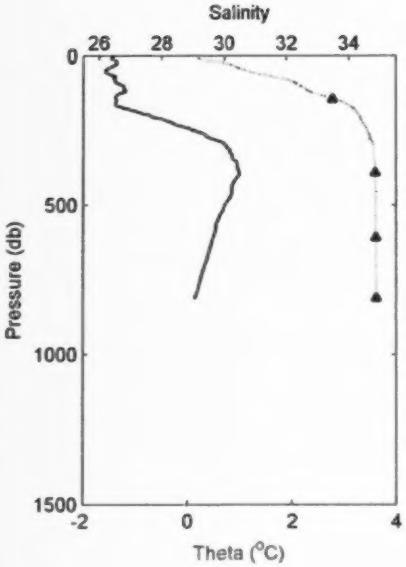


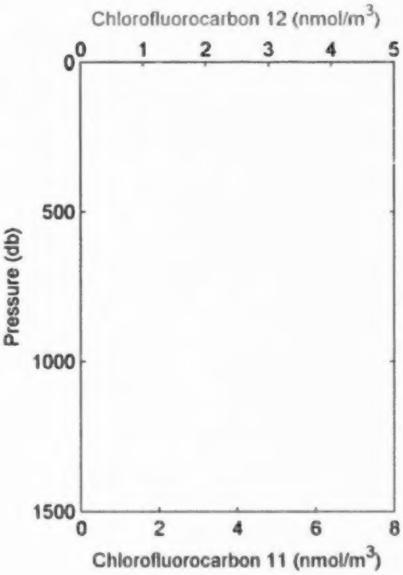


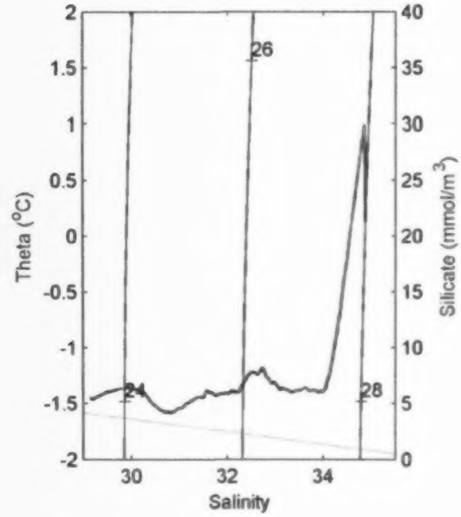


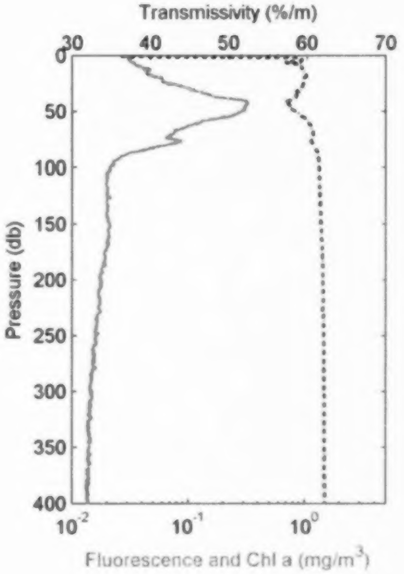


2005-04: Cast 29 Station CB11

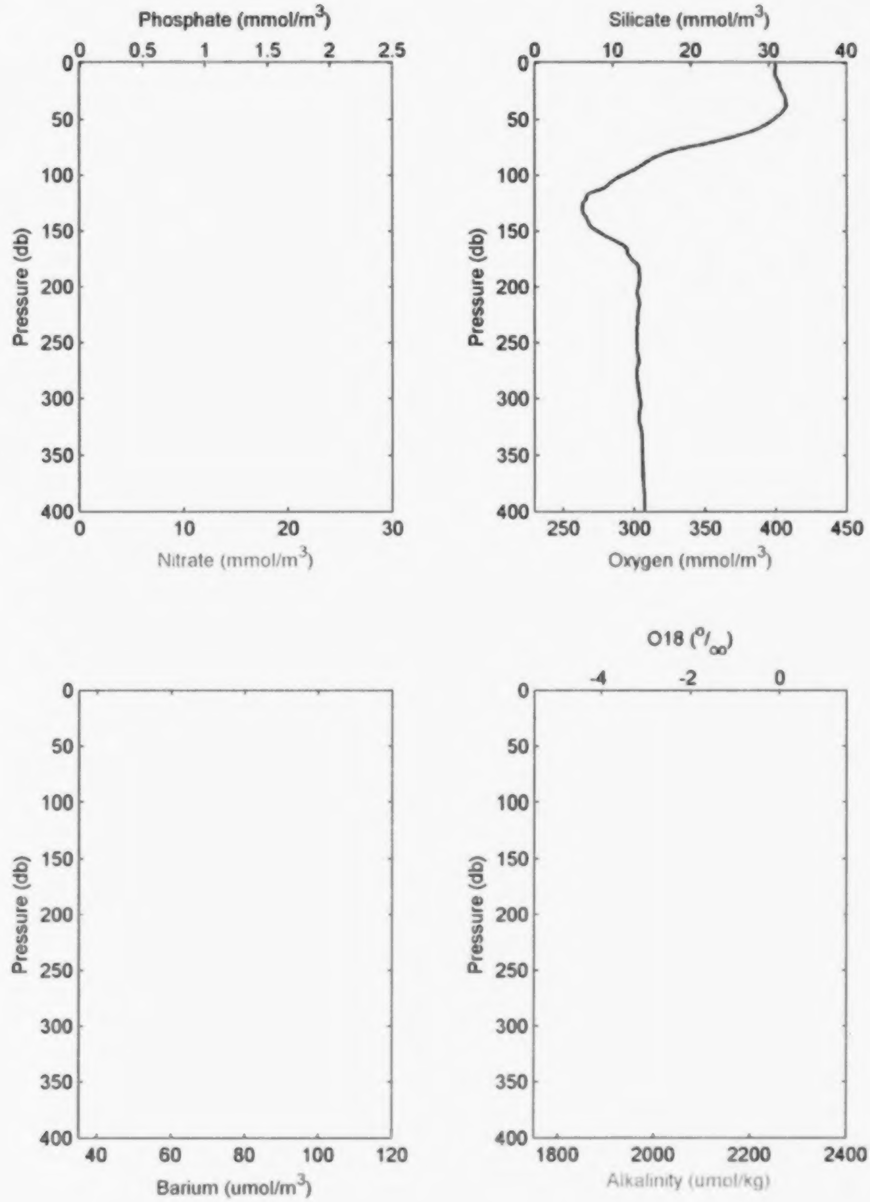




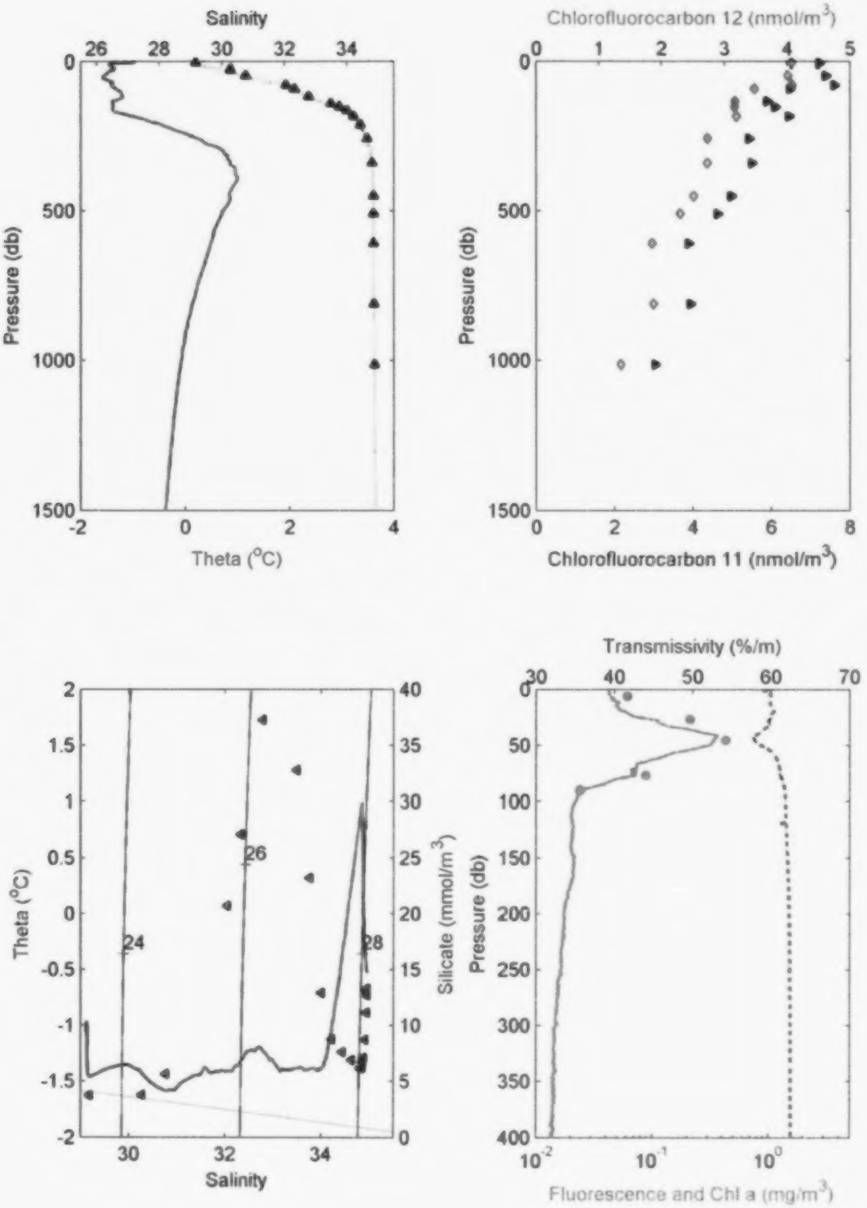




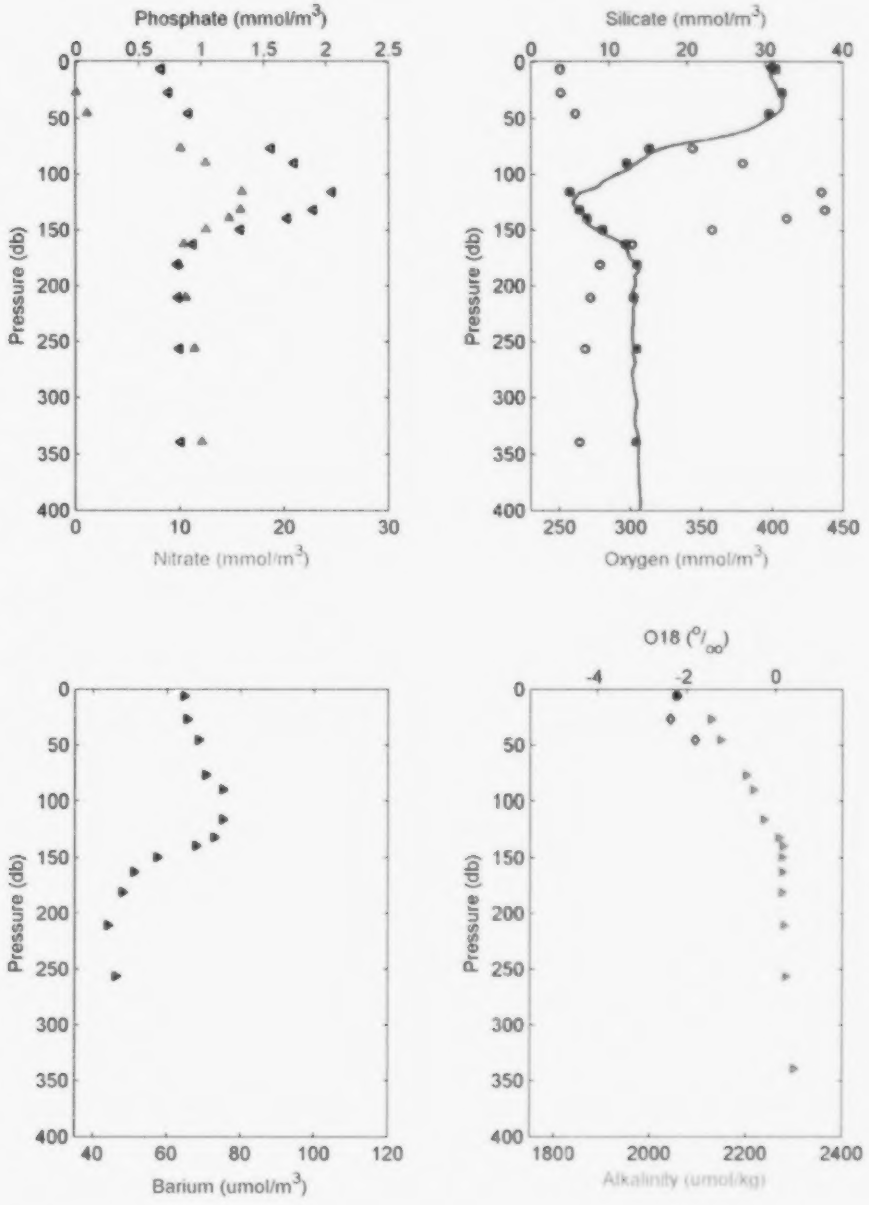
2005-04: Cast 29 Station CB11



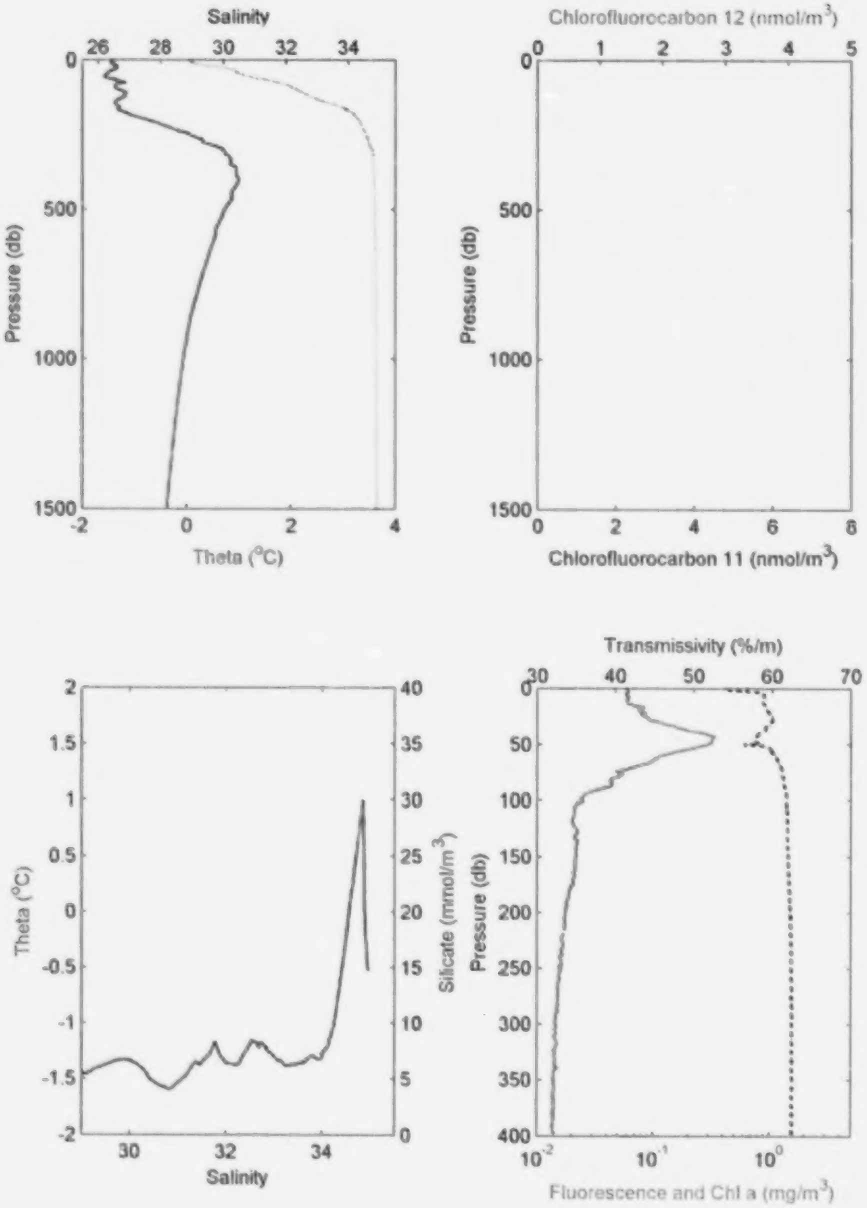
2005-04: Cast 30 Station CB11



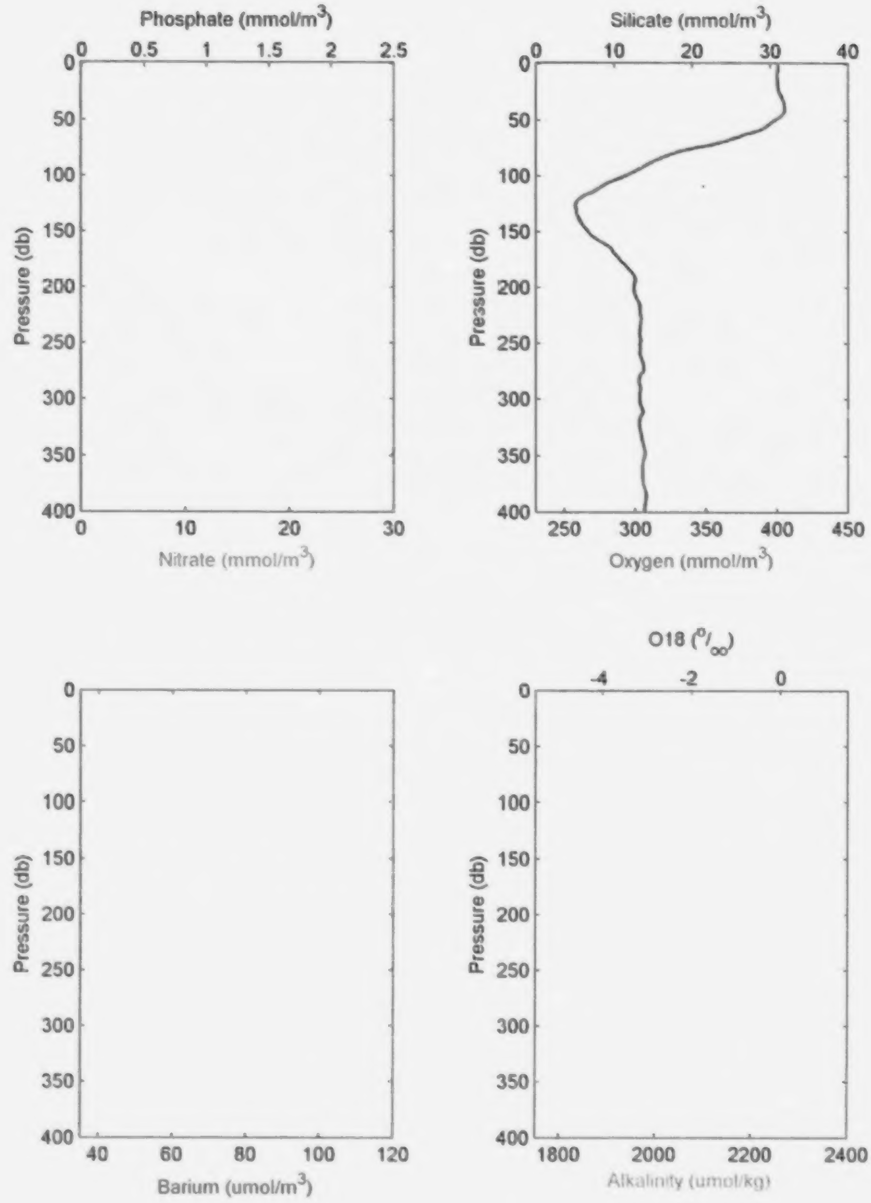
2005-04: Cast 30 Station CB11



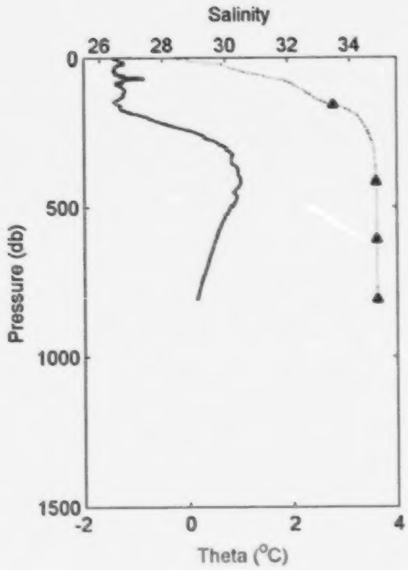
2005-04: Cast 31 Station Ice$_f$low

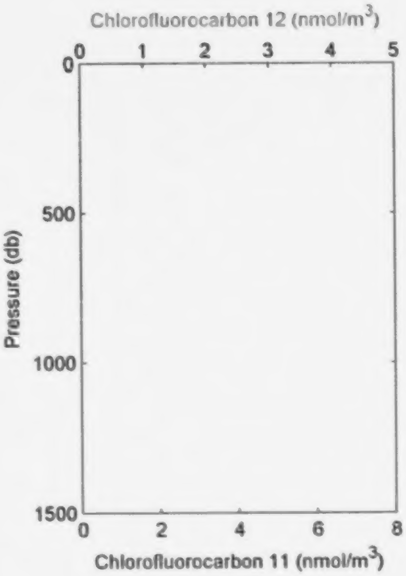


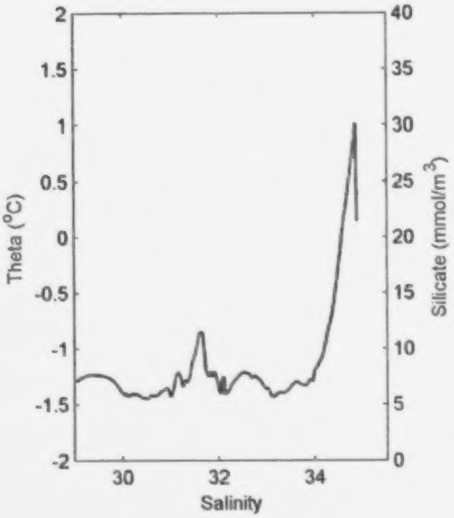
2005-04: Cast 31 Station Ice$_f$low

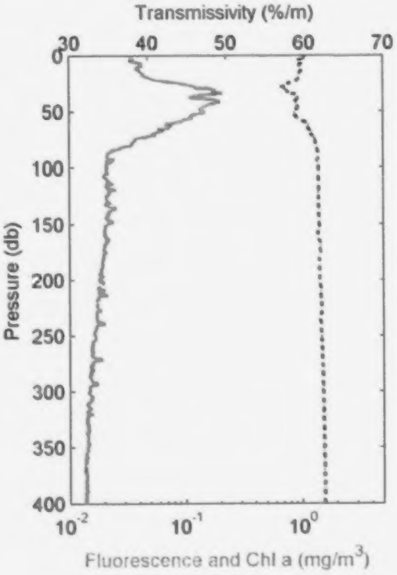


2005-04: Cast 32 Station CB10

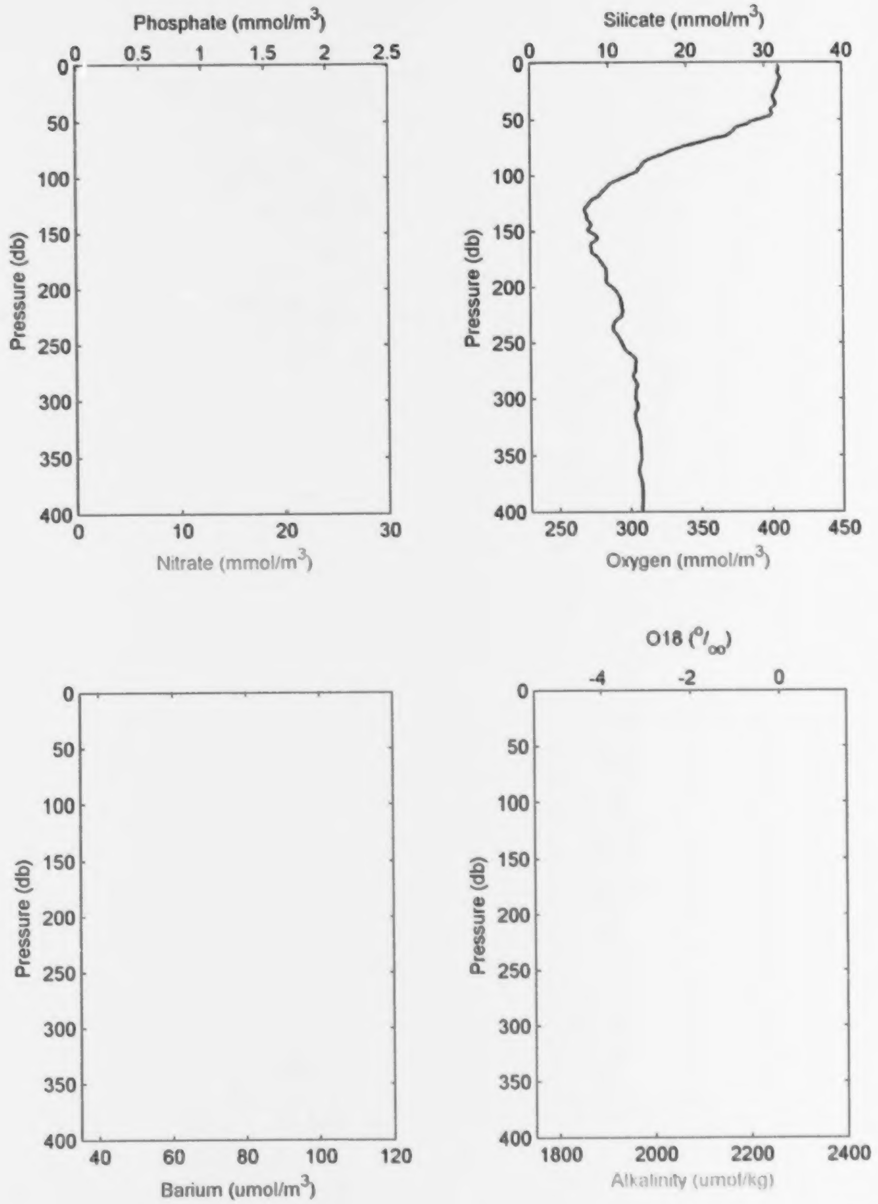




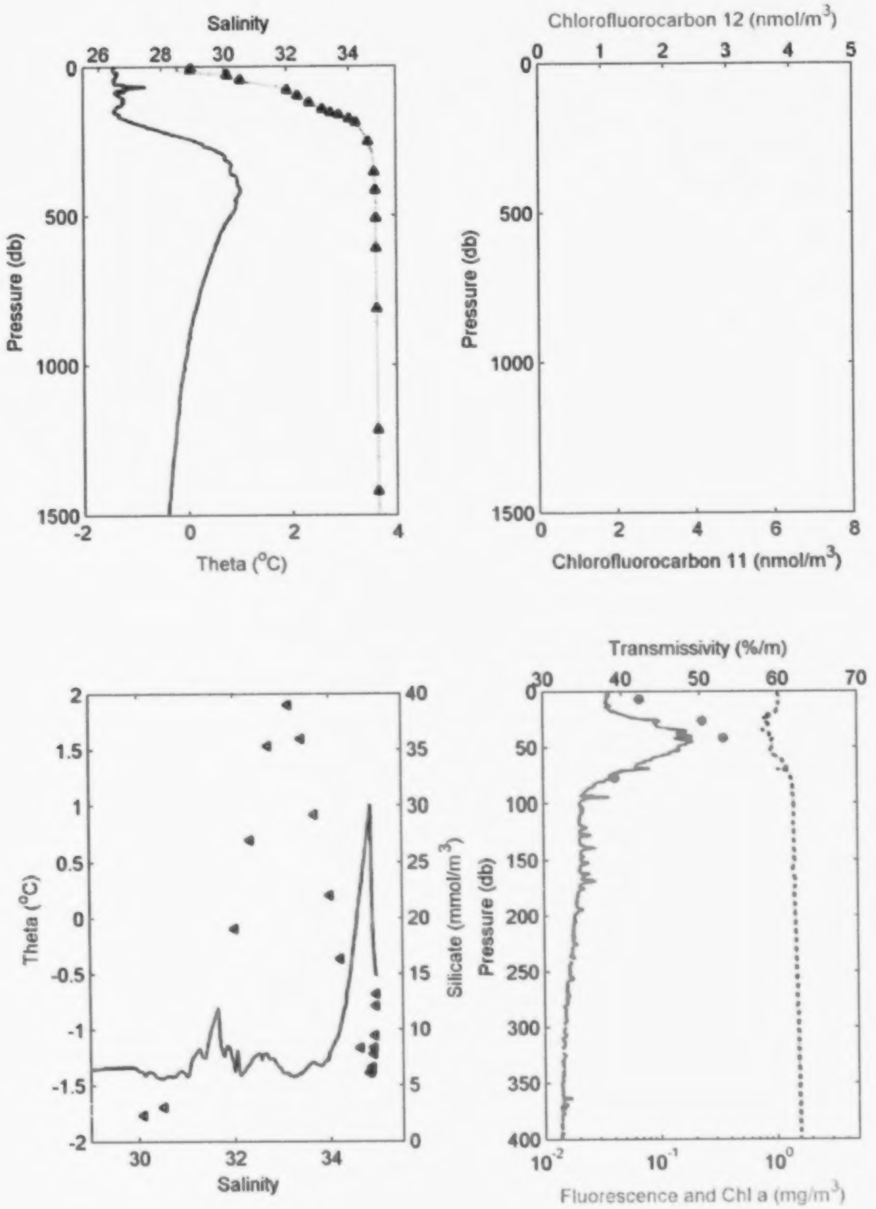




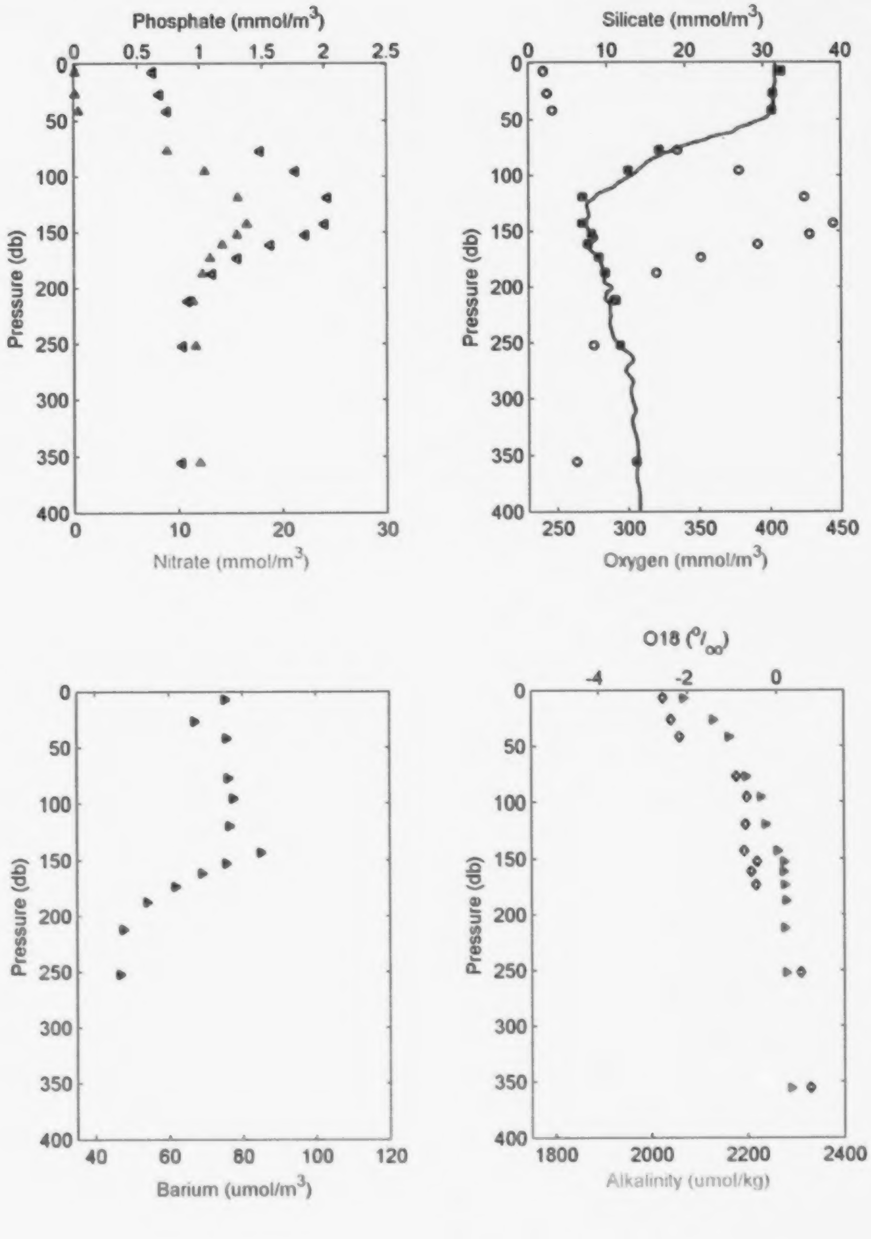
2005-04: Cast 32 Station CB10



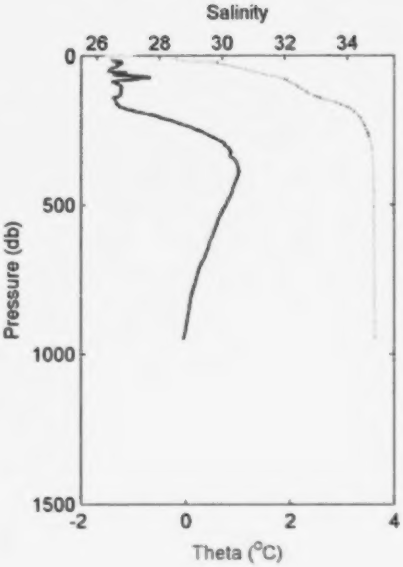
2005-04: Cast 33 Station CB10

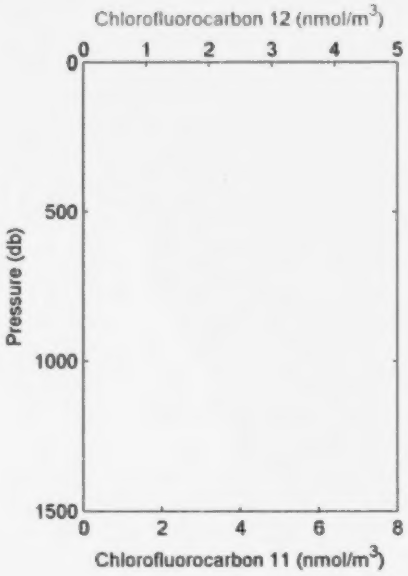


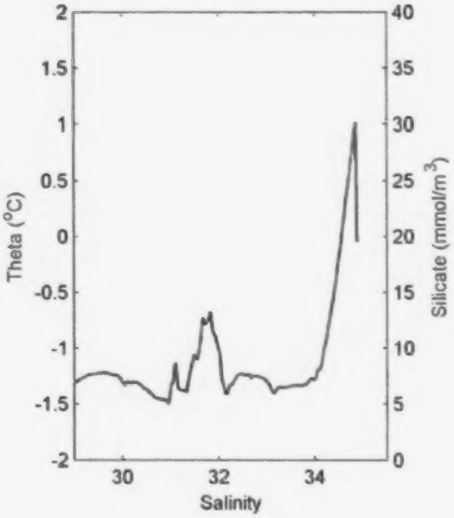
2005-04: Cast 33 Station CB10

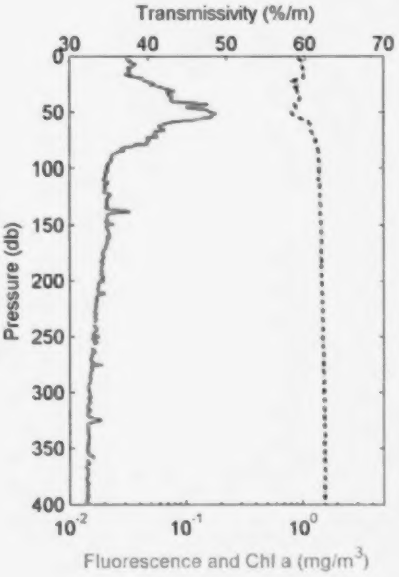


2005-04: Cast 34 Station CB10A









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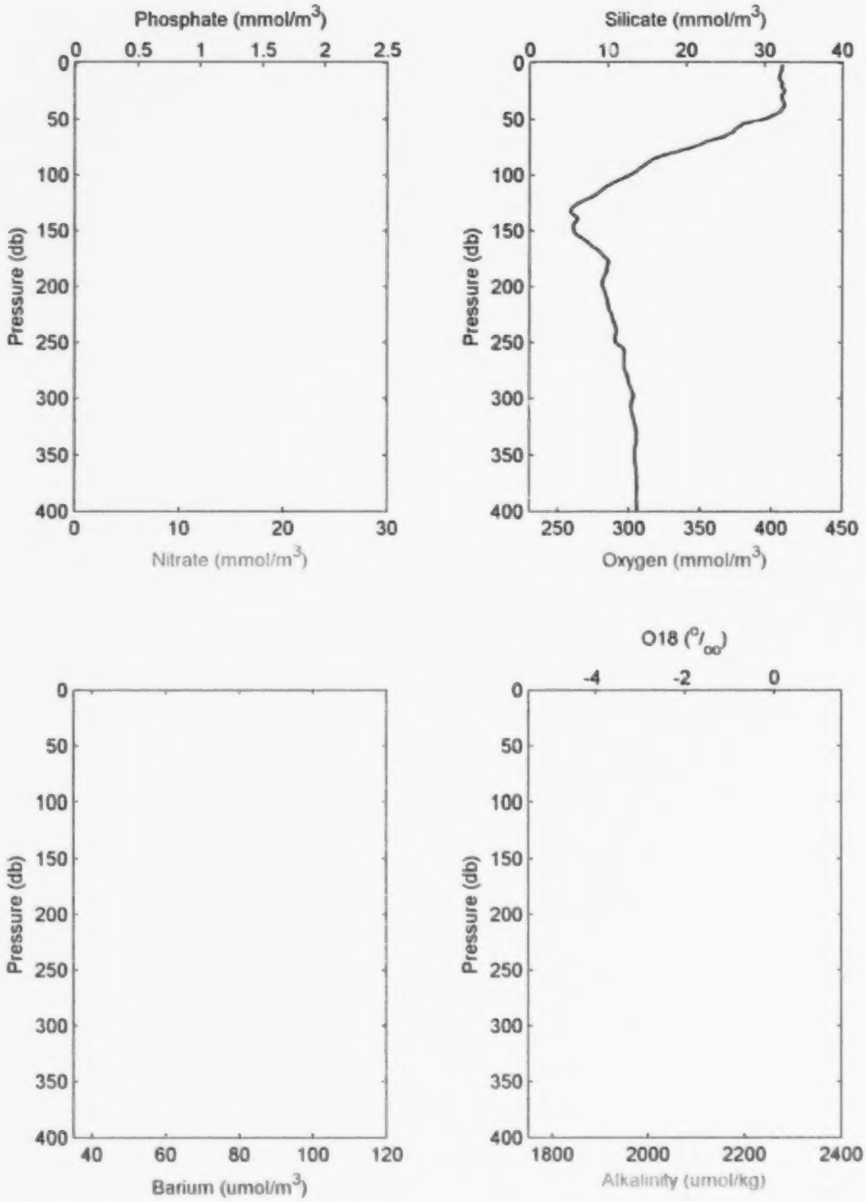
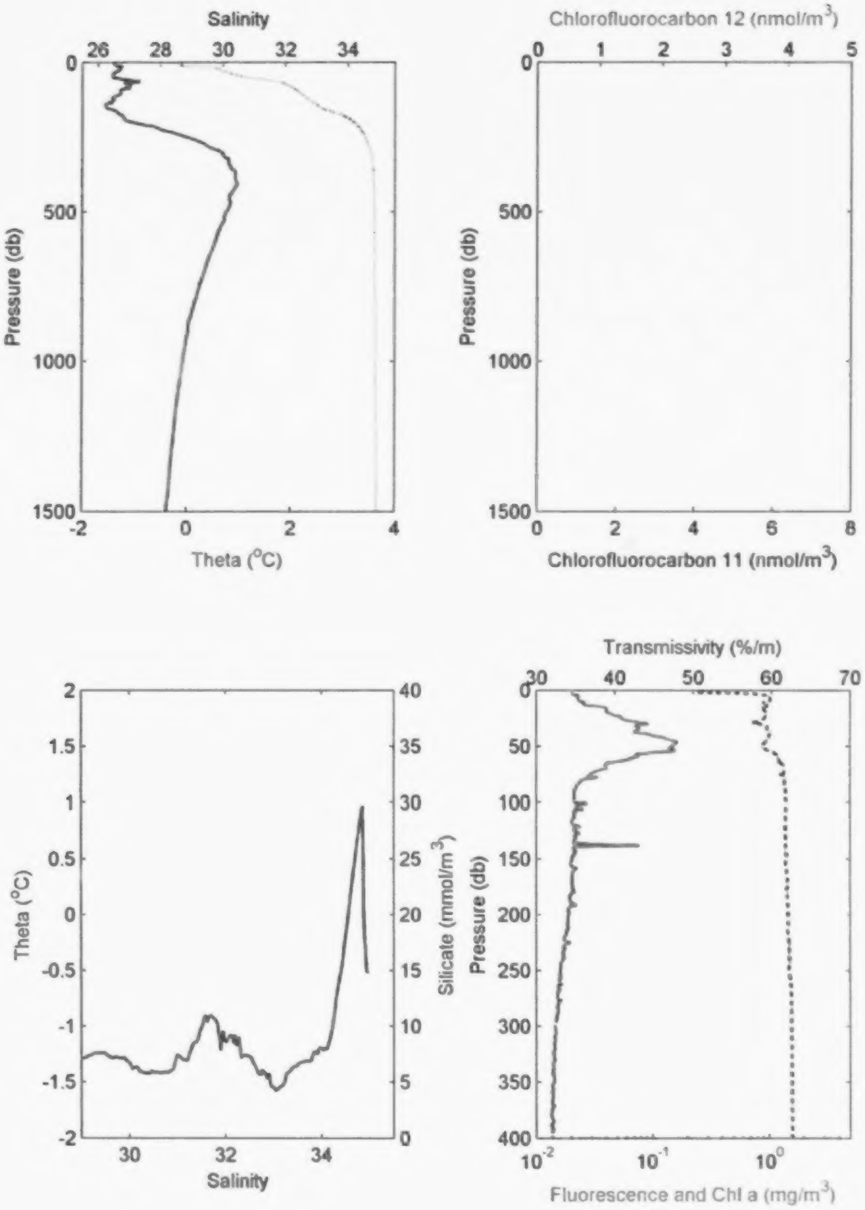
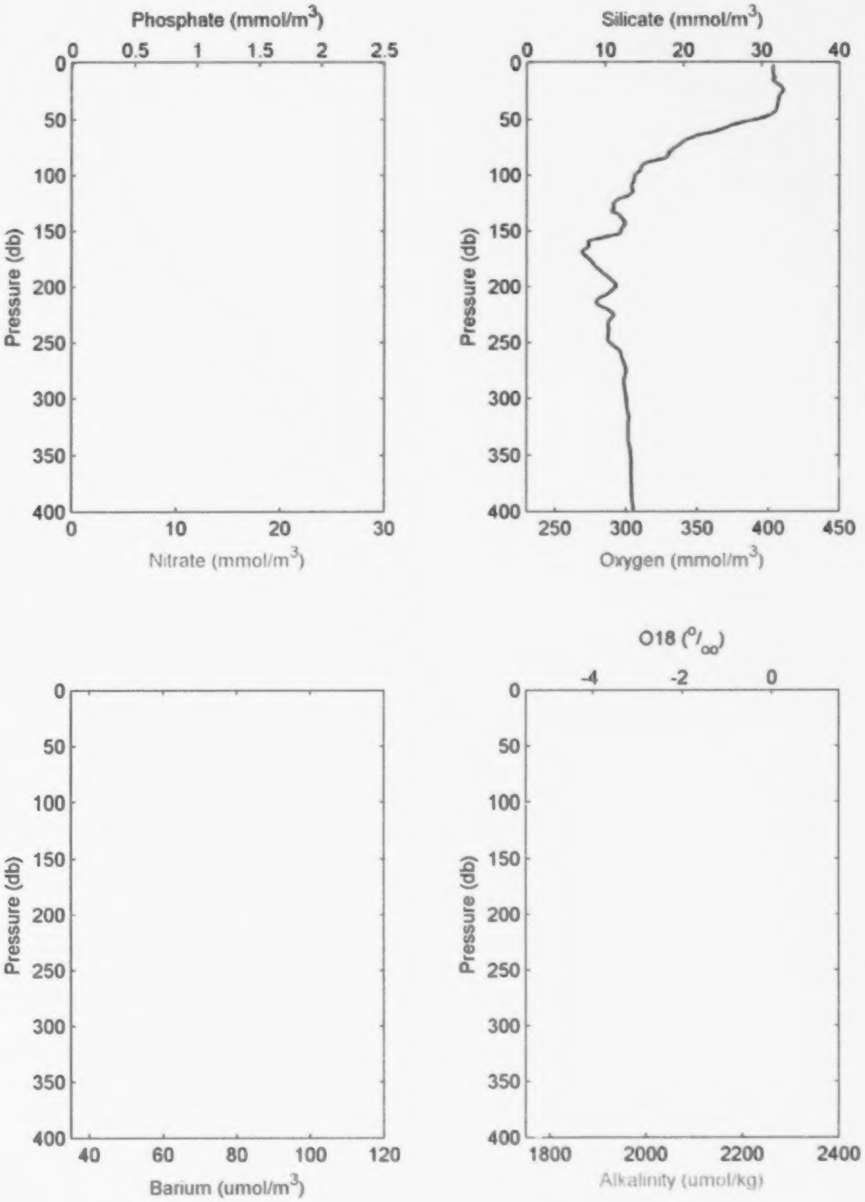


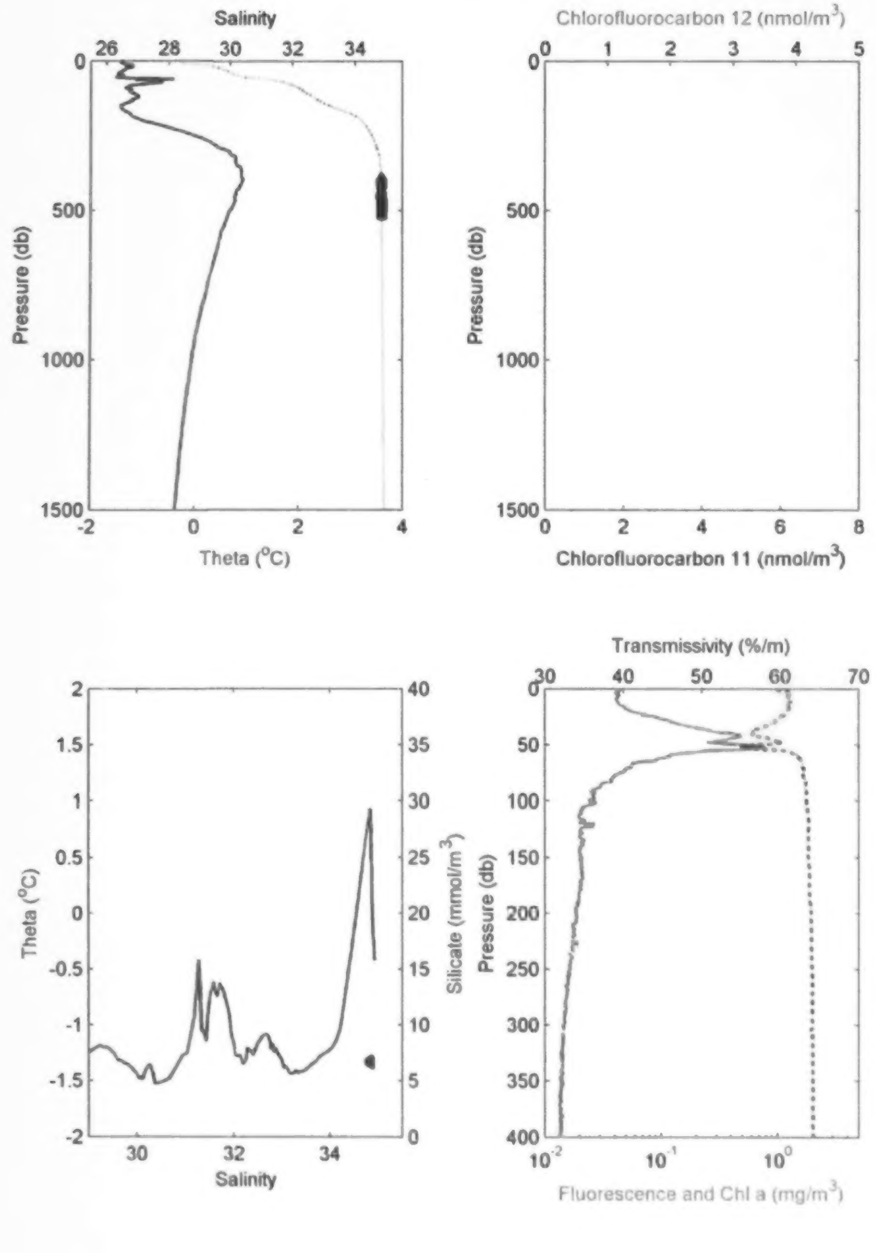
2005-04: Cast 35 Station CB10B



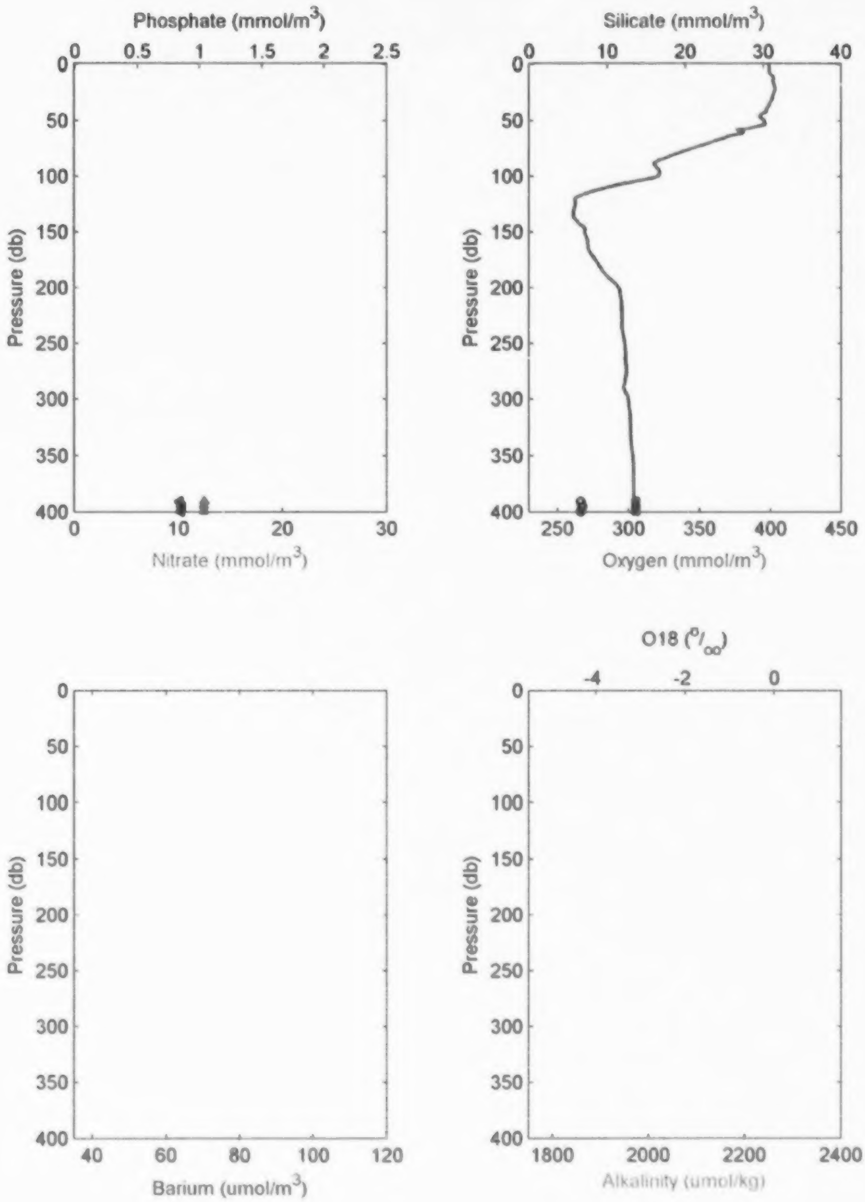
2005-04: Cast 35 Station CB10B



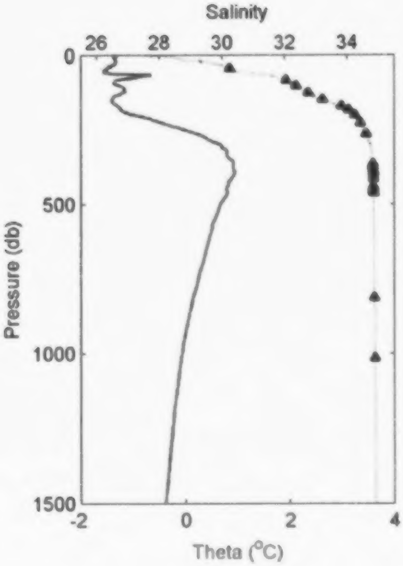
2005-04: Cast 36 Station CB9

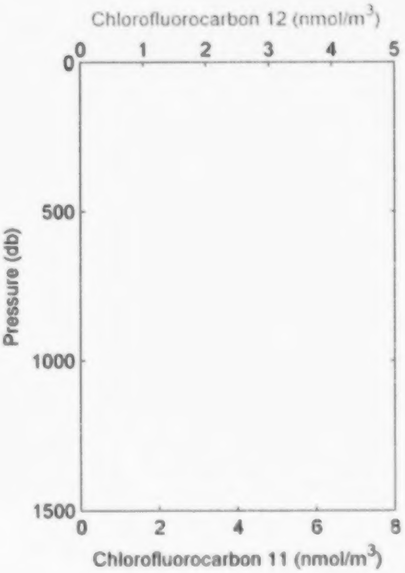


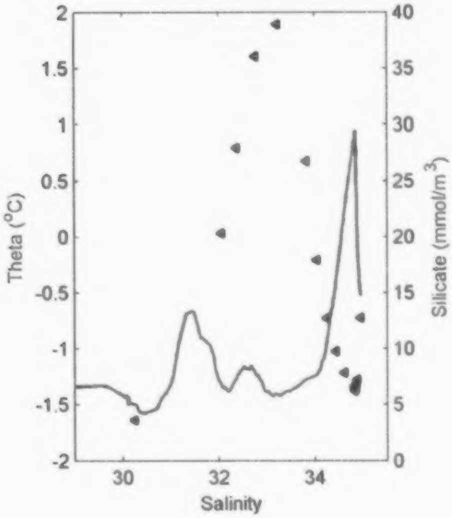
2005-04: Cast 36 Station CB9

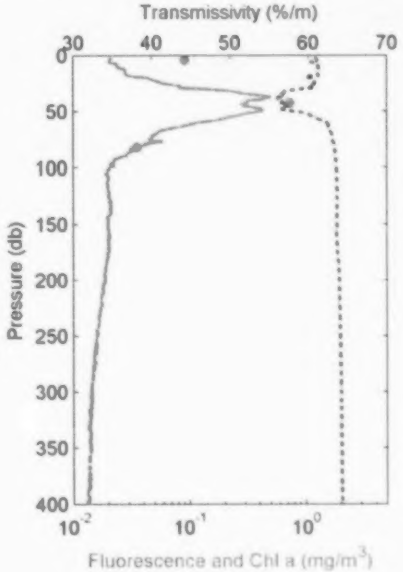


2005-04: Cast 37 Station CB12

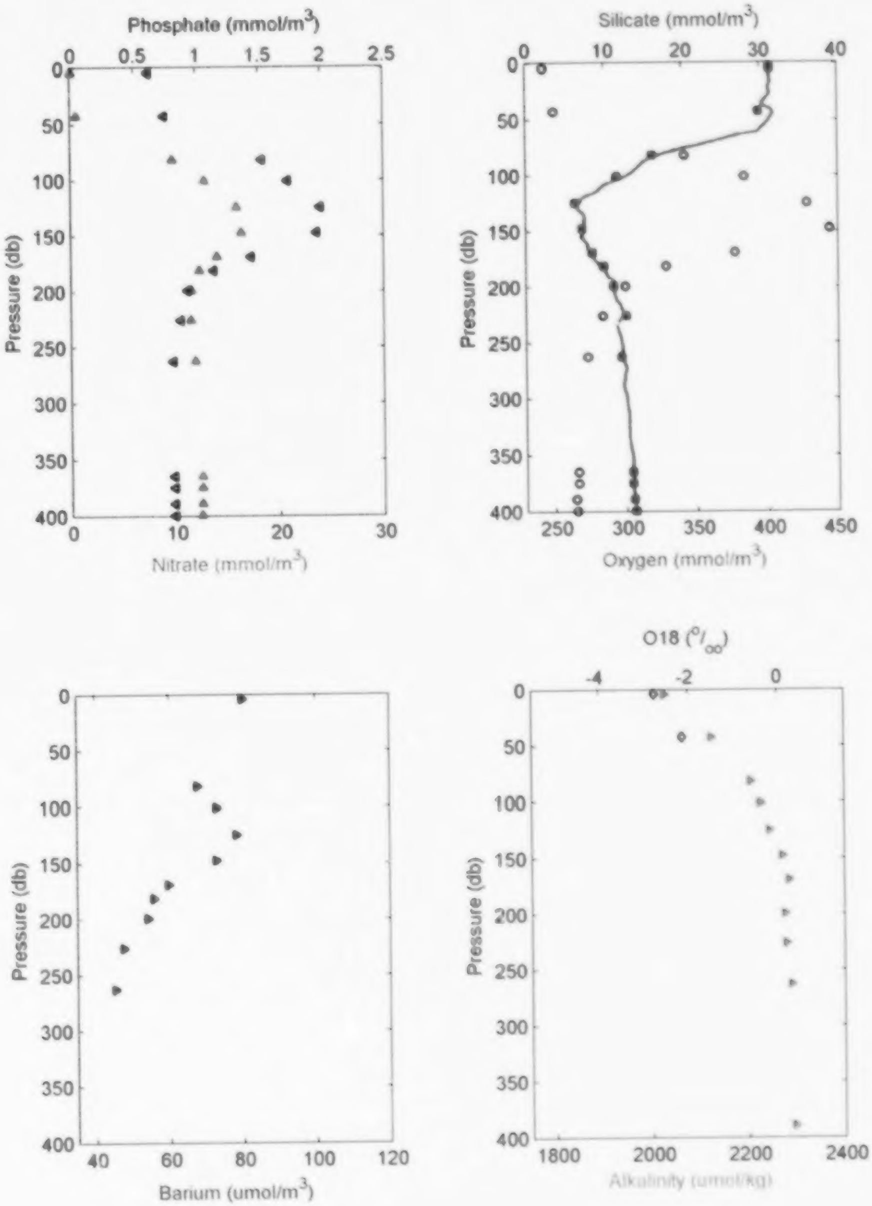




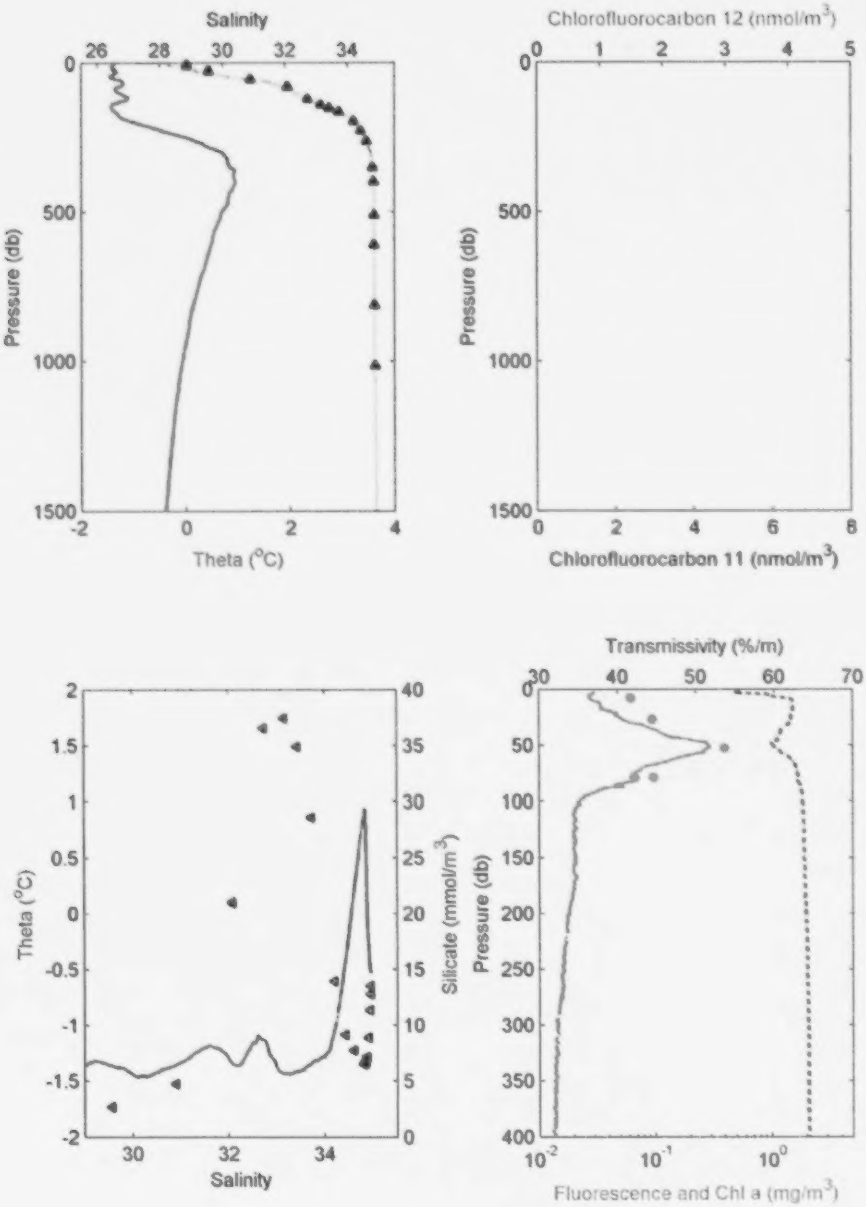




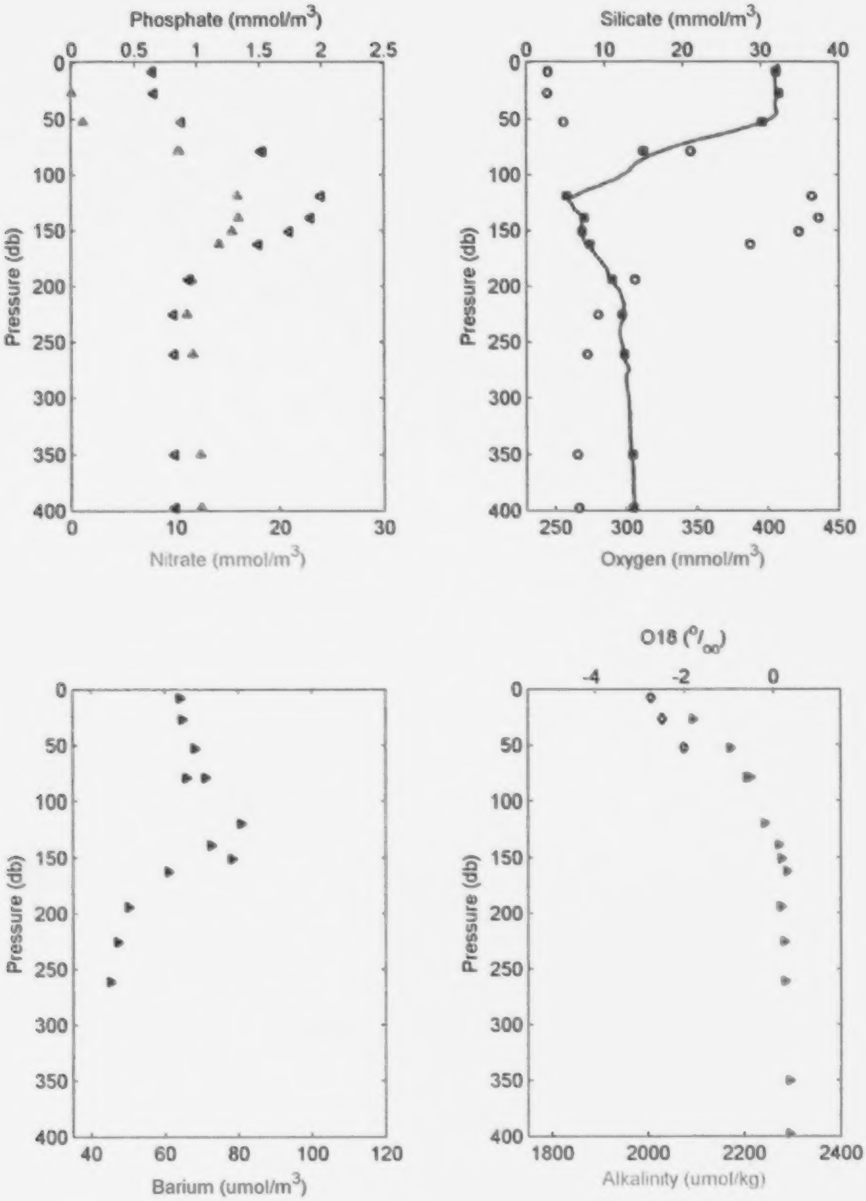
2005-04: Cast 37 Station CB12



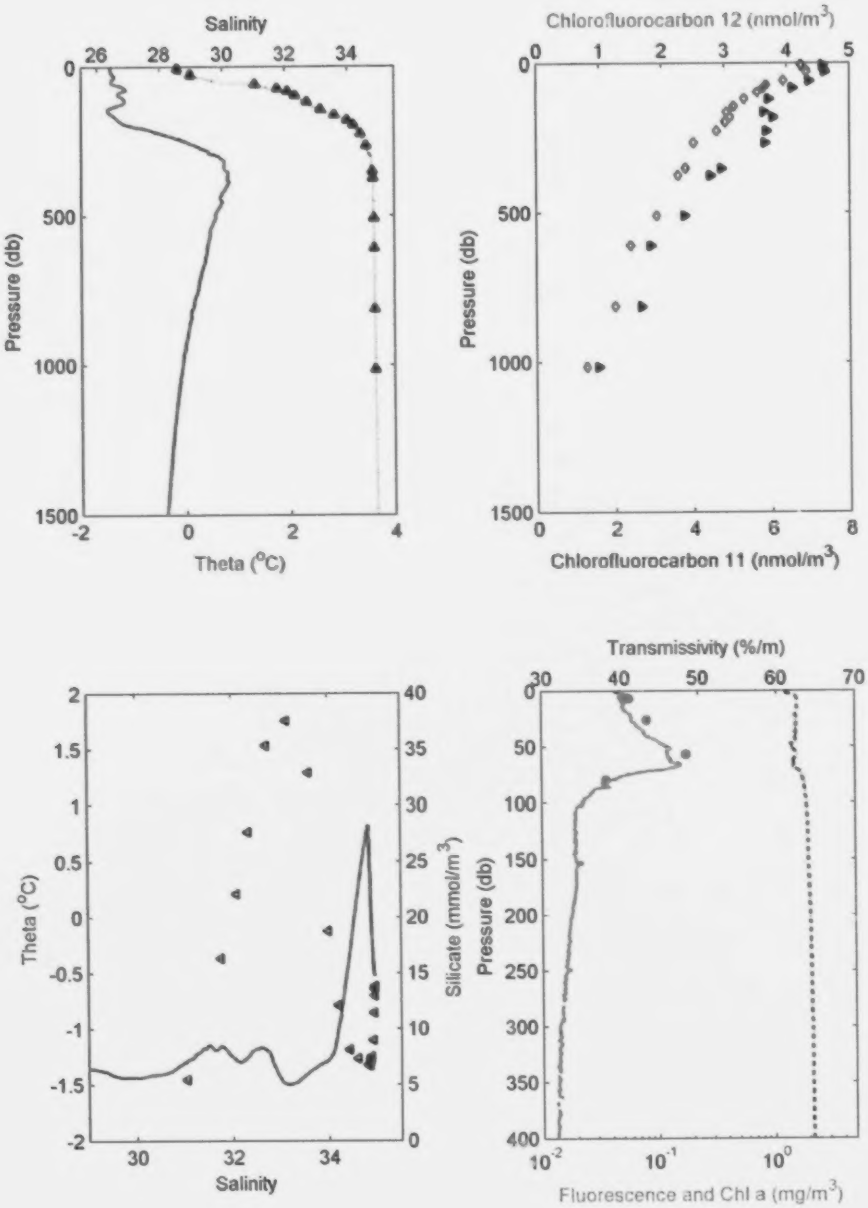
2005-04: Cast 38 Station CB13



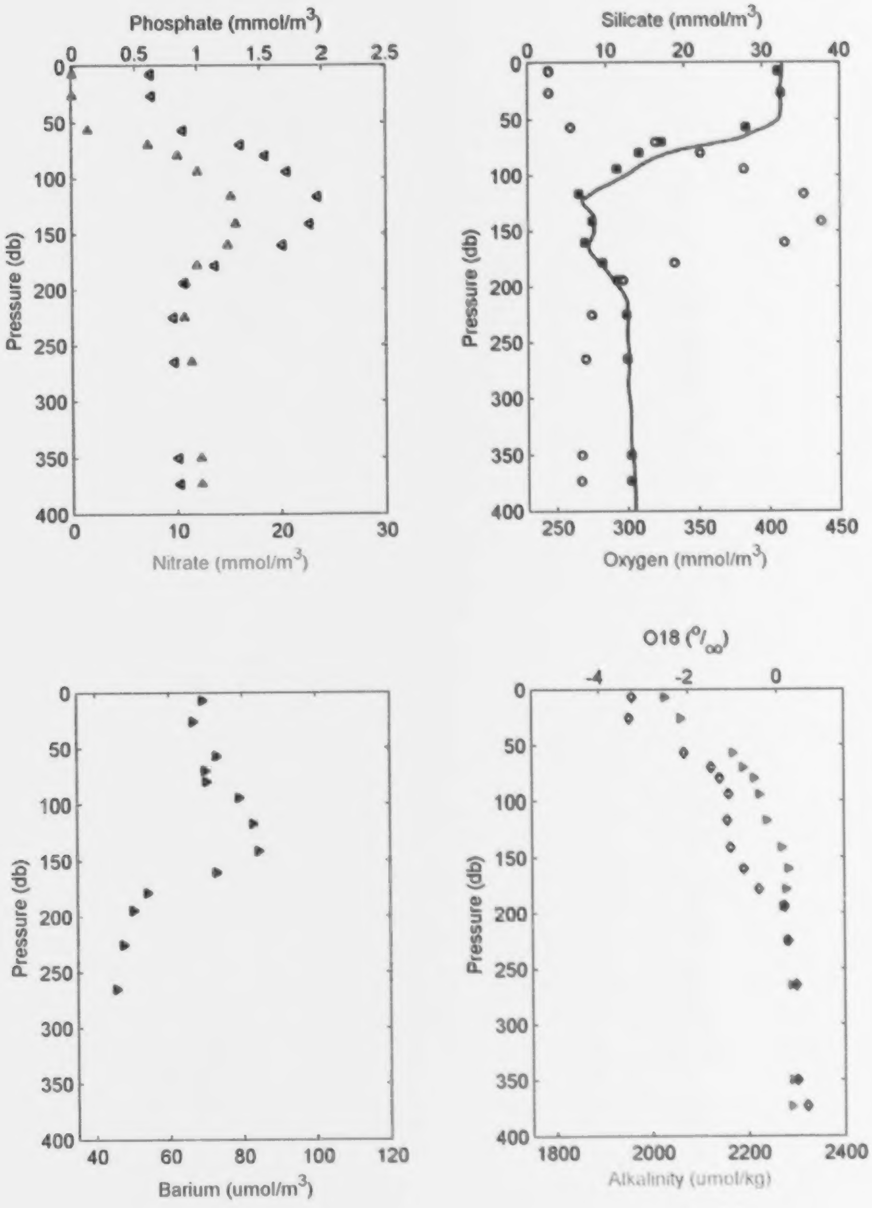
2005-04: Cast 38 Station CB13



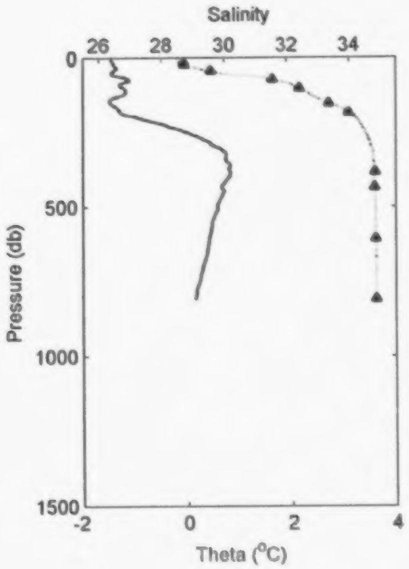
2005-04: Cast 39 Station CB15

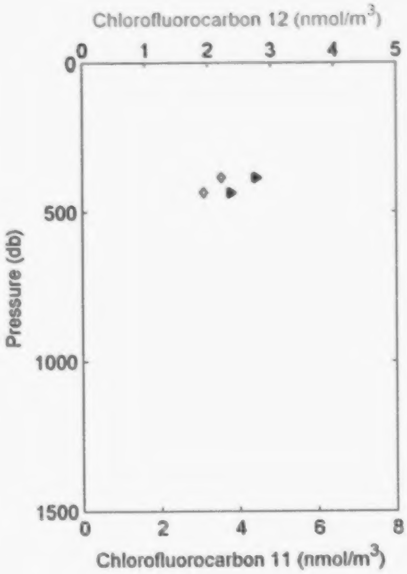


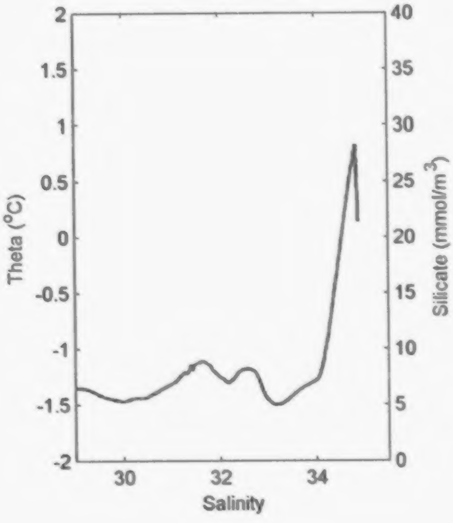
2005-04: Cast 39 Station CB15

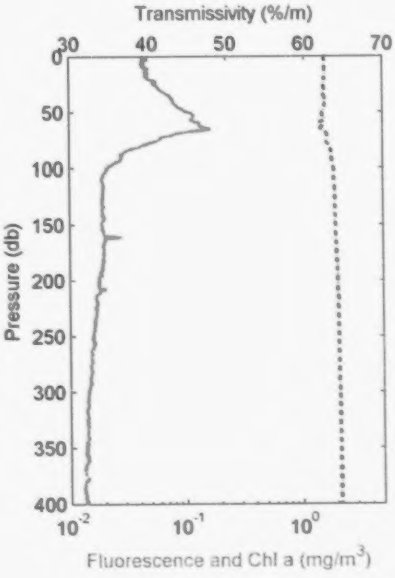


2005-04: Cast 40 Station CB15

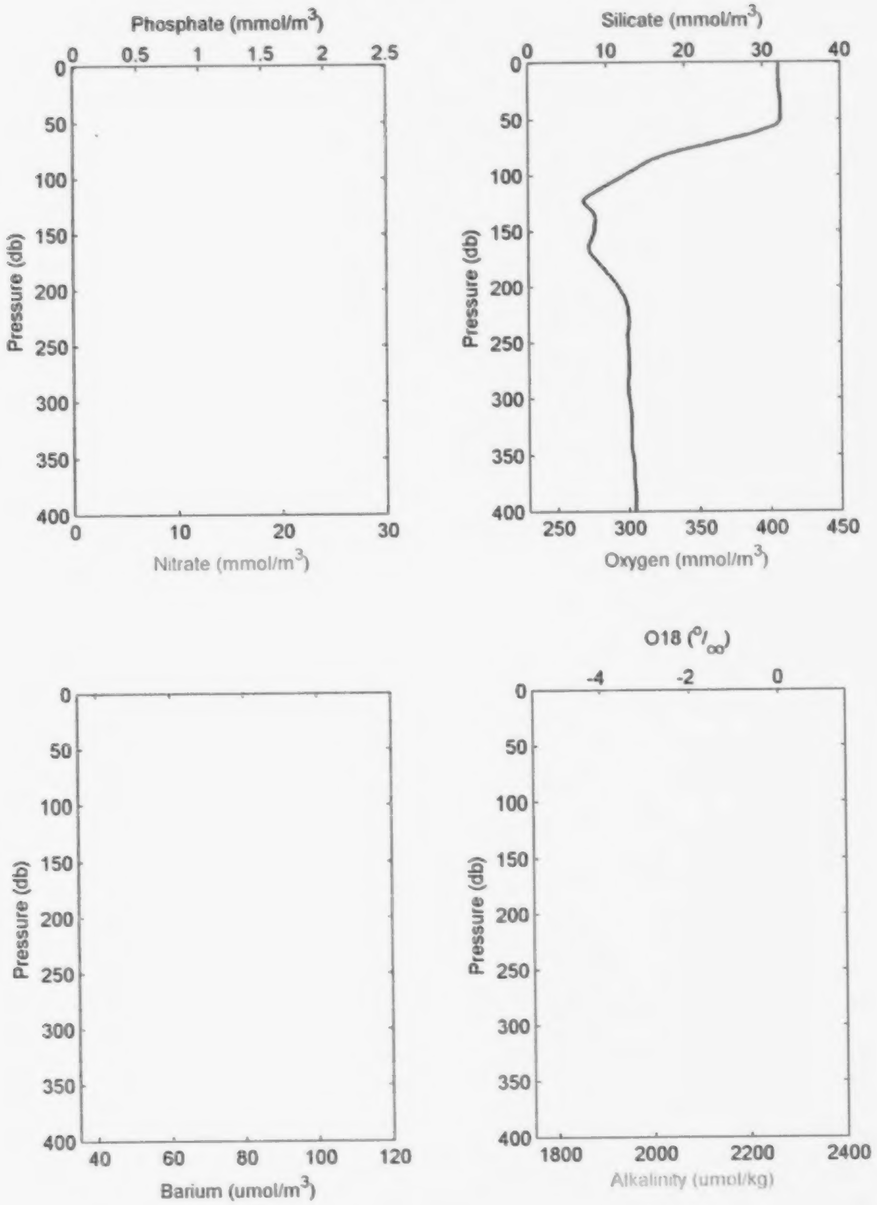




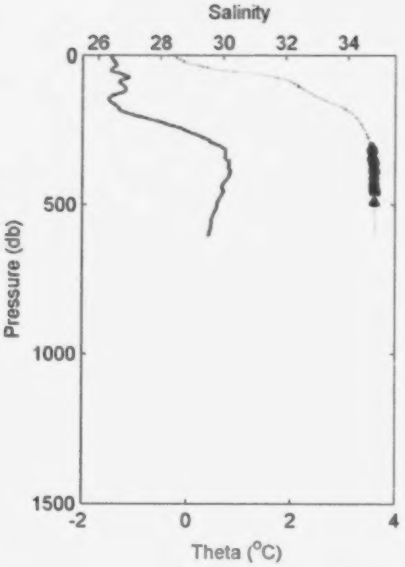


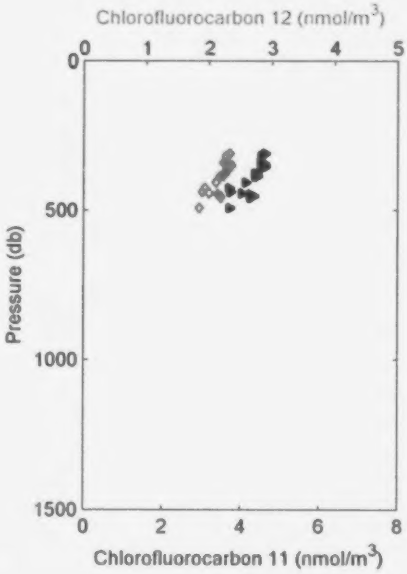


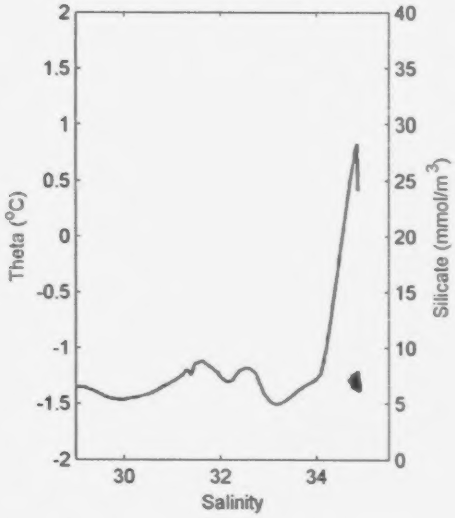
2005-04: Cast 40 Station CB15

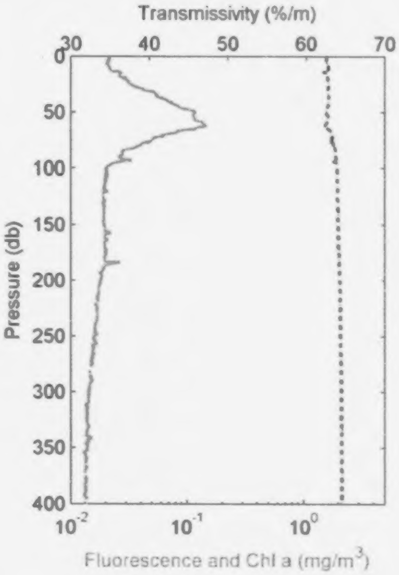


2005-04: Cast 41 Station CB15

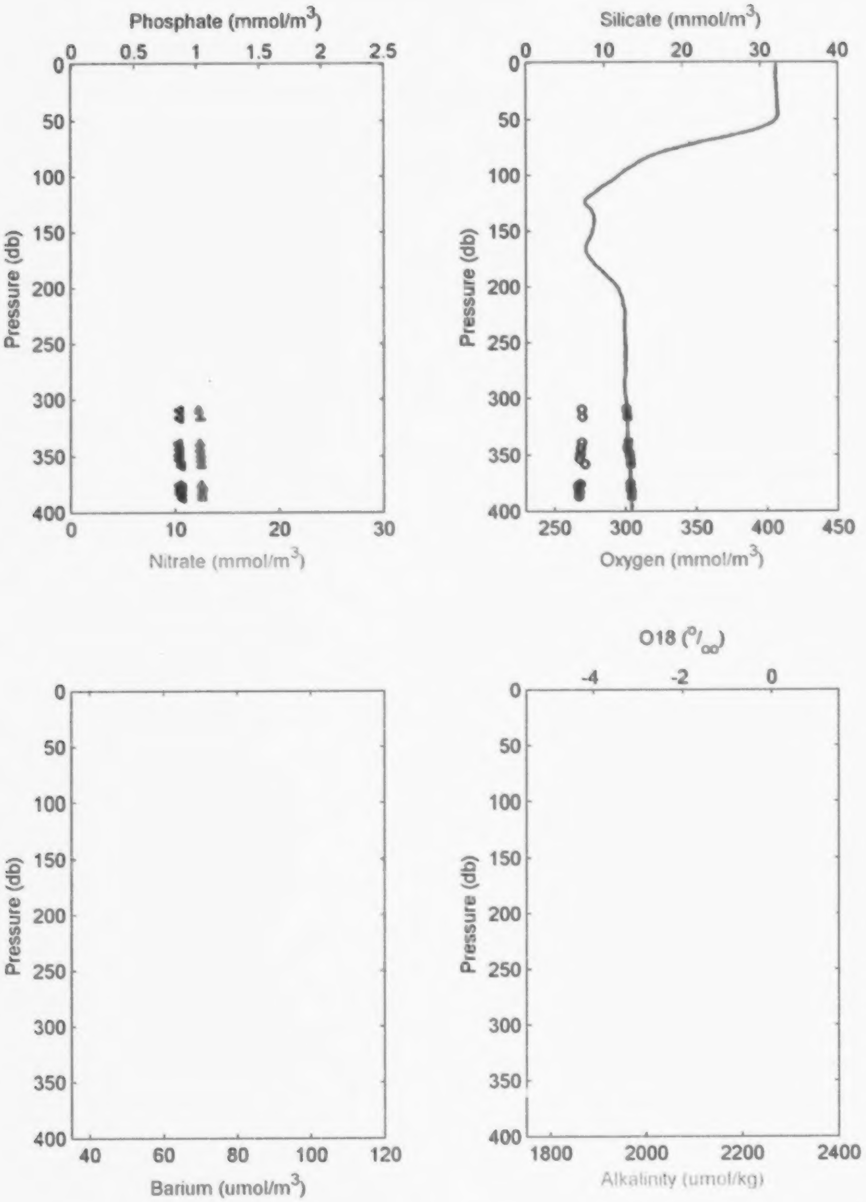




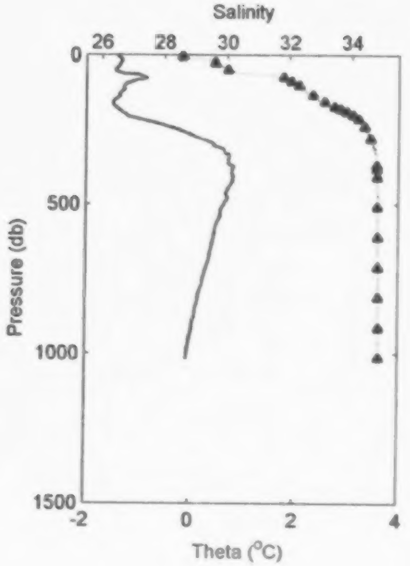


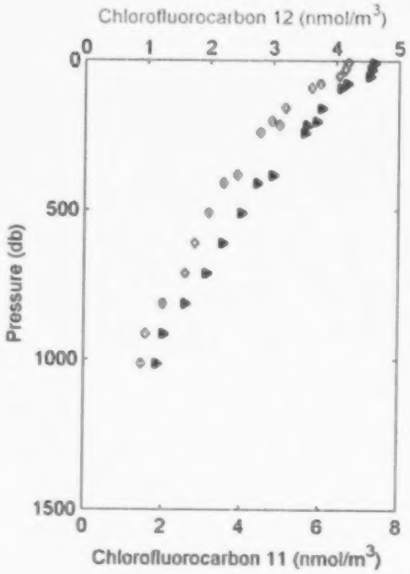


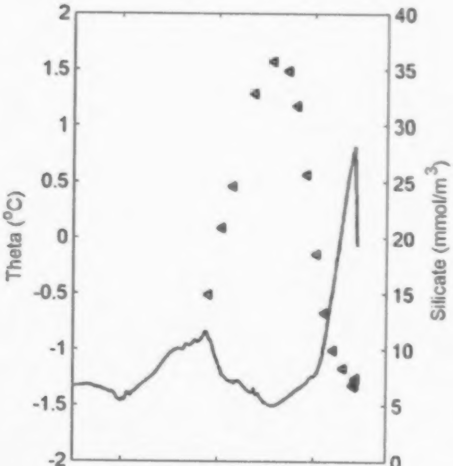
2005-04: Cast 41 Station CB15

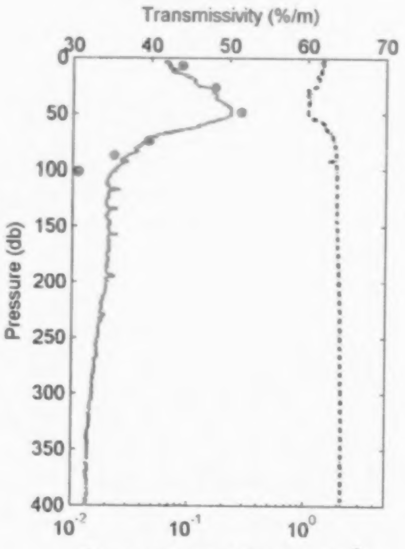


2005-04: Cast 42 Station CB17

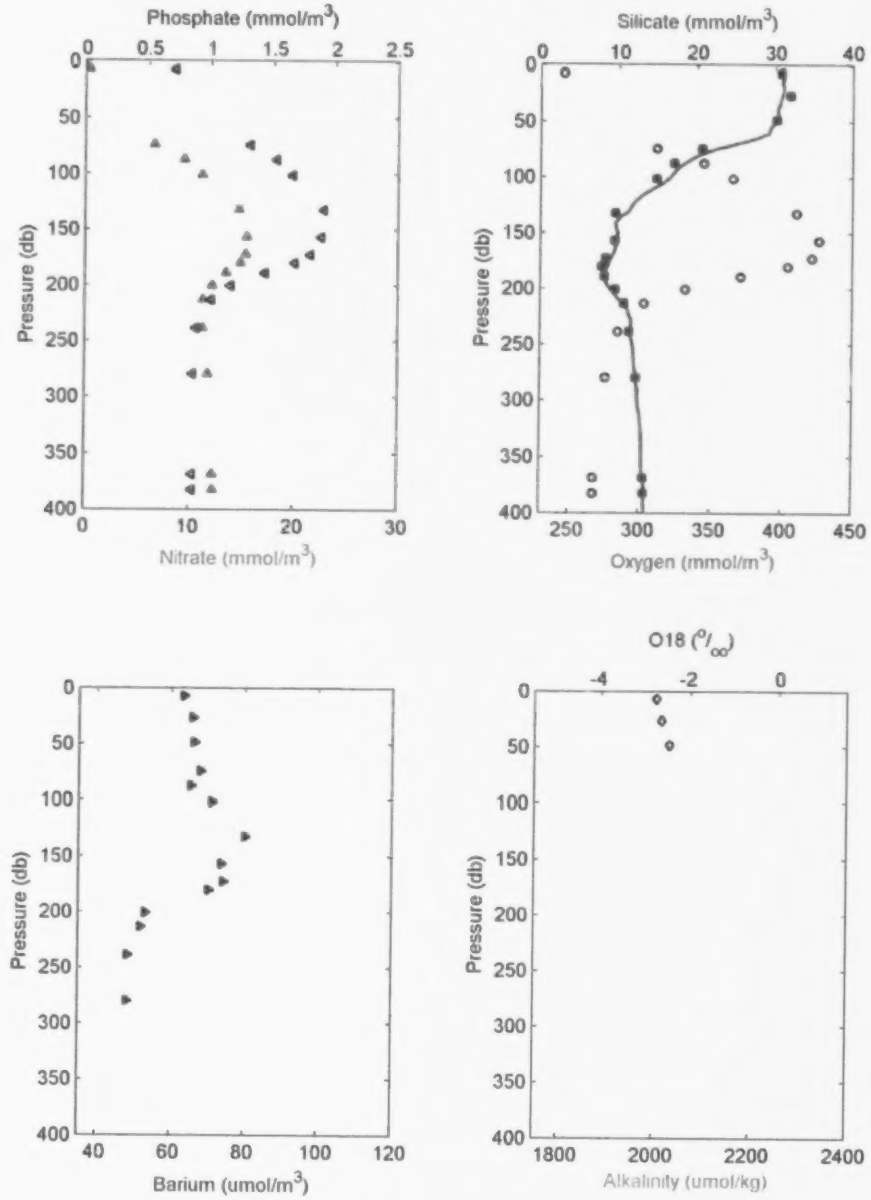




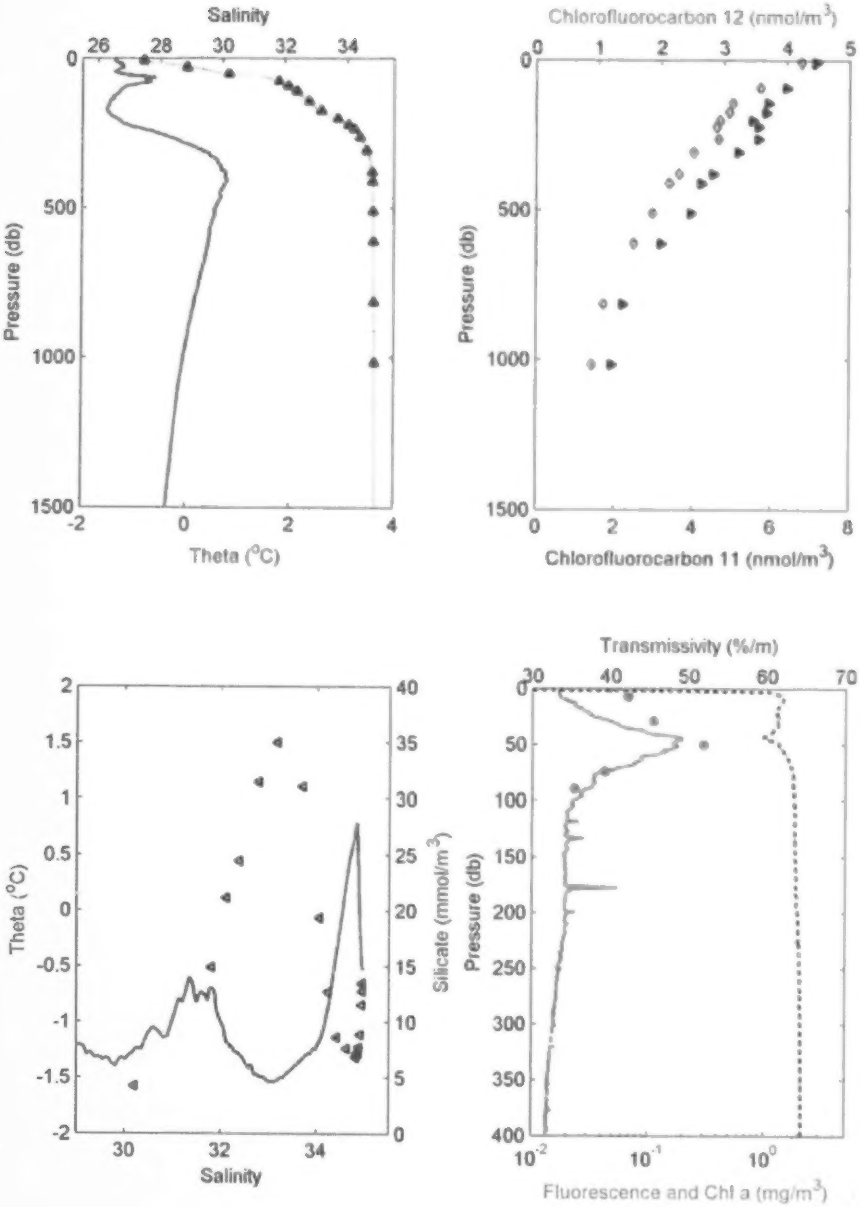




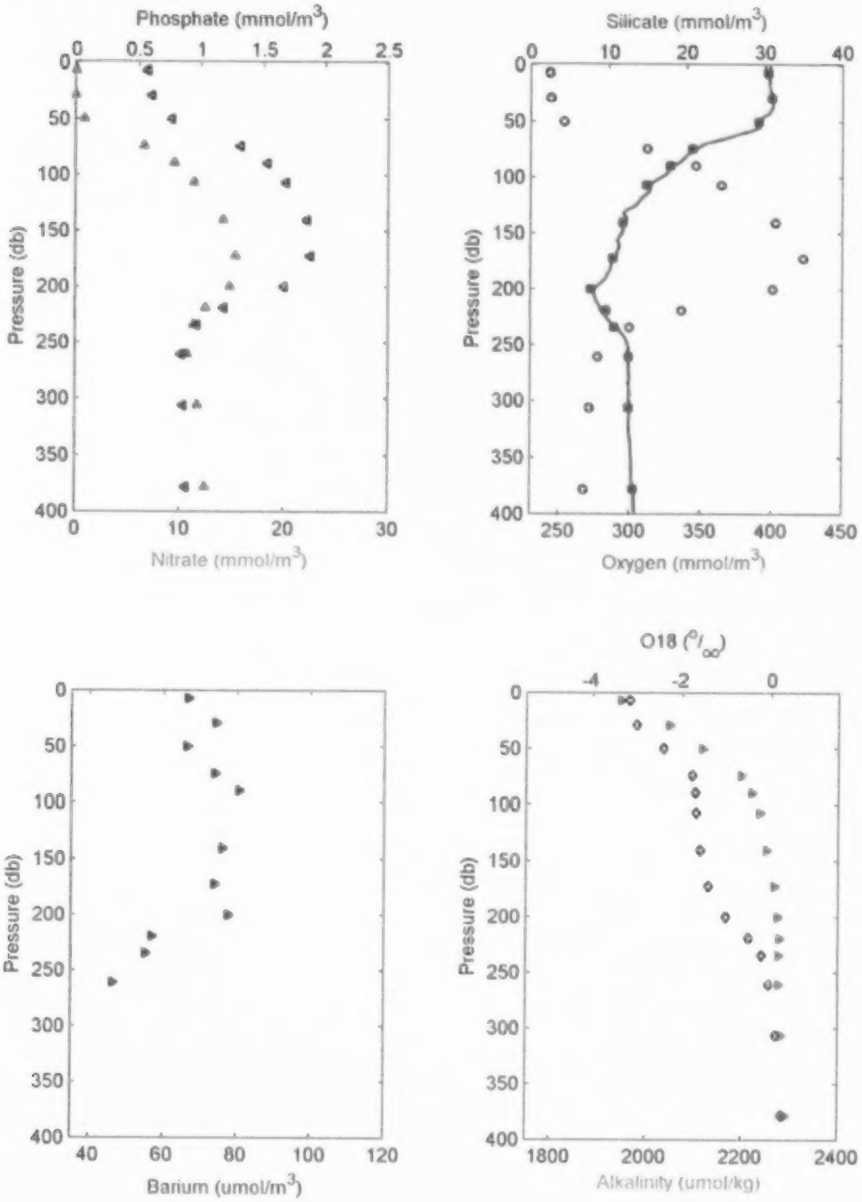
2005-04: Cast 42 Station CB17



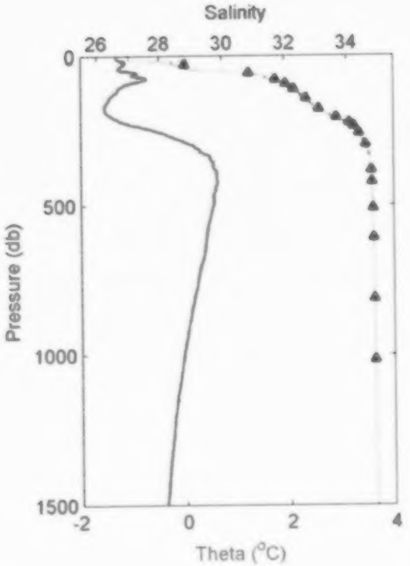
2005-04: Cast 43 Station CB18

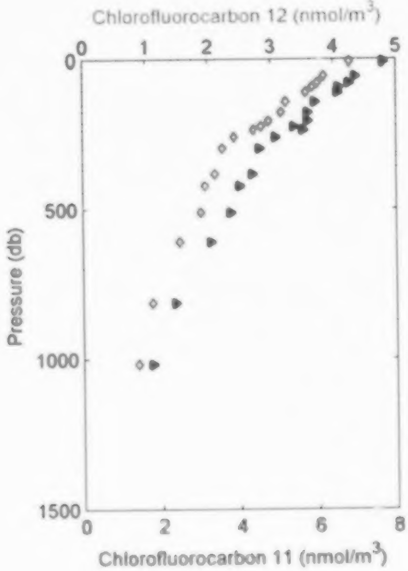


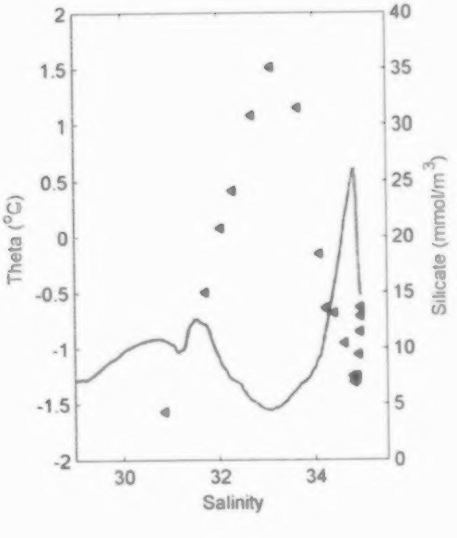
2005-04: Cast 43 Station CB18

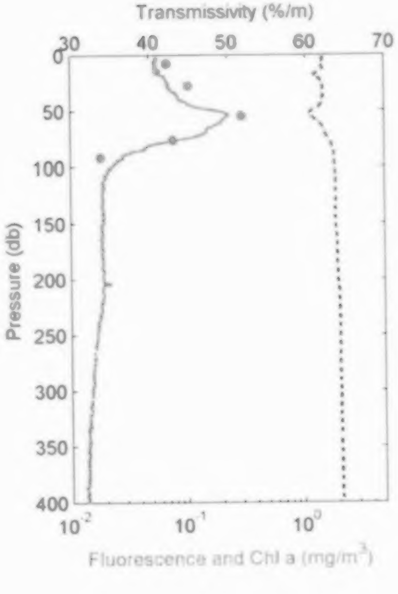


2005-04: Cast 44 Station CB21

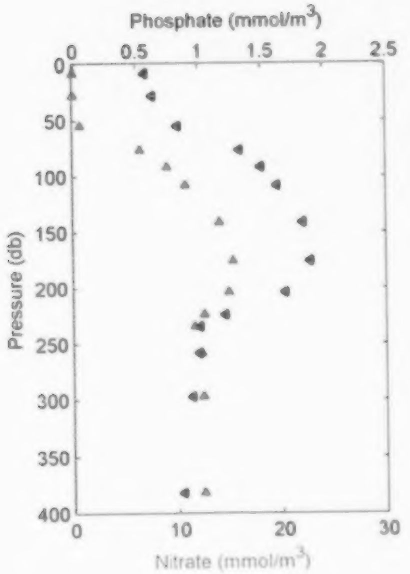


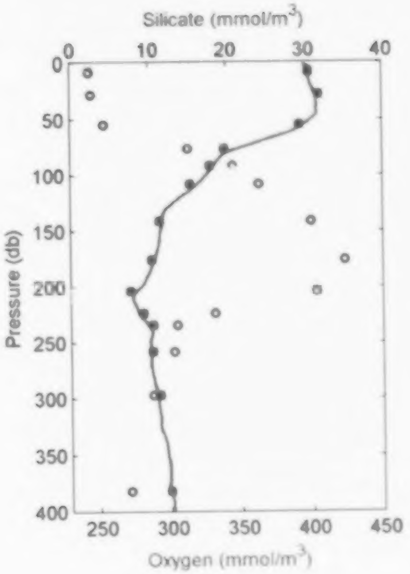


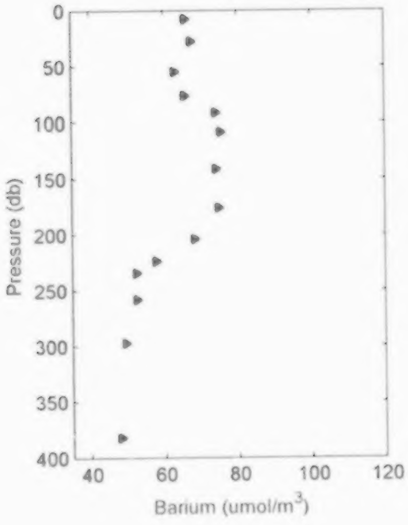


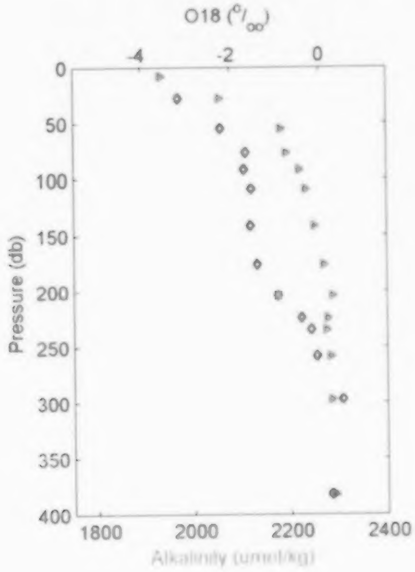


2005-04: Cast 44 Station CB21

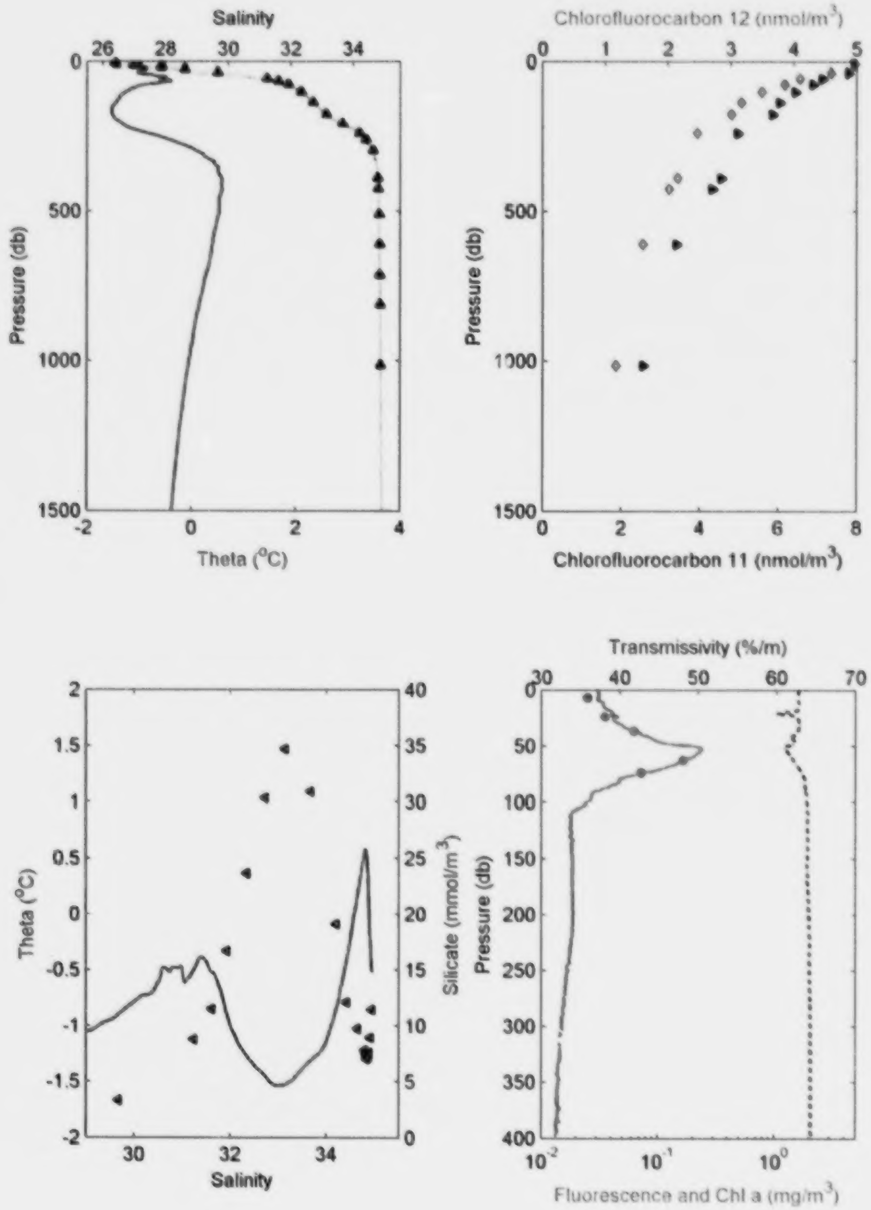




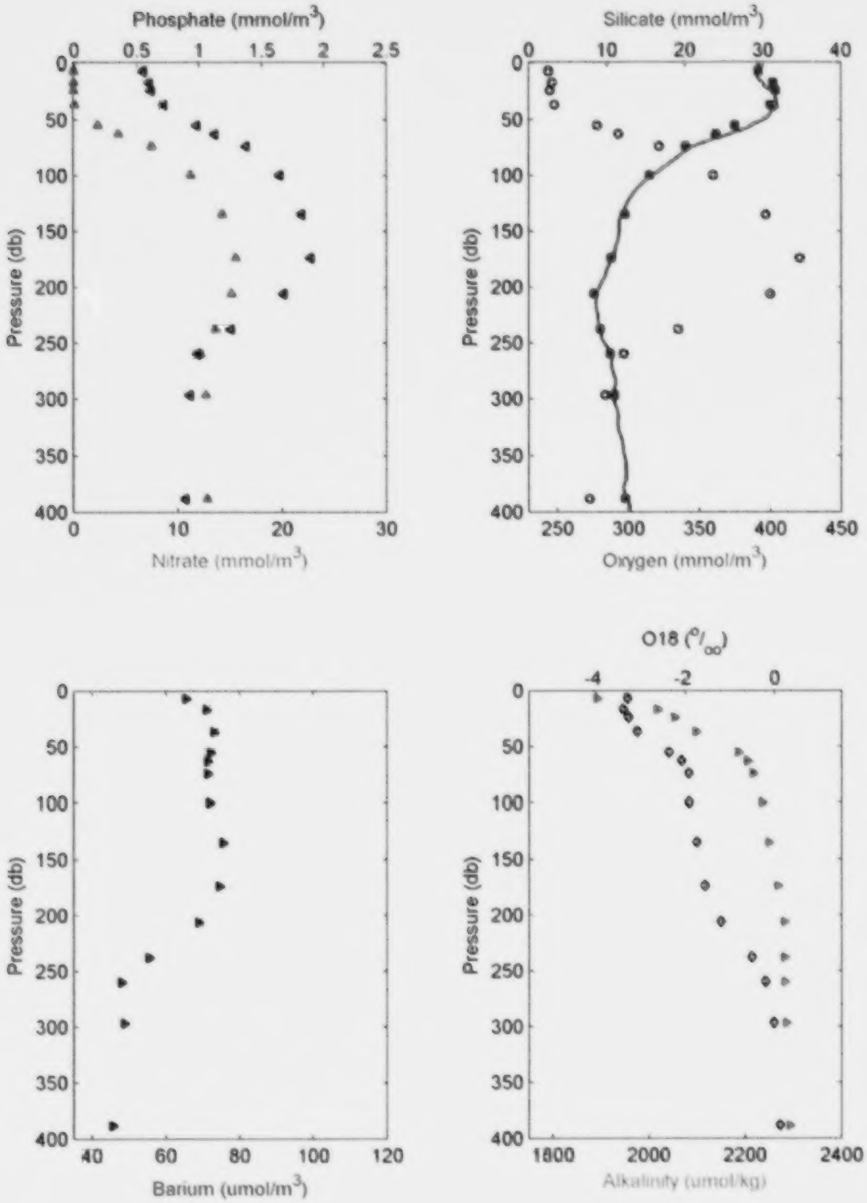




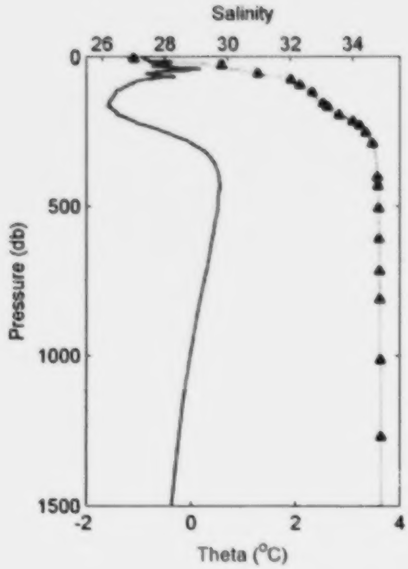
2005-04: Cast 45 Station CB27

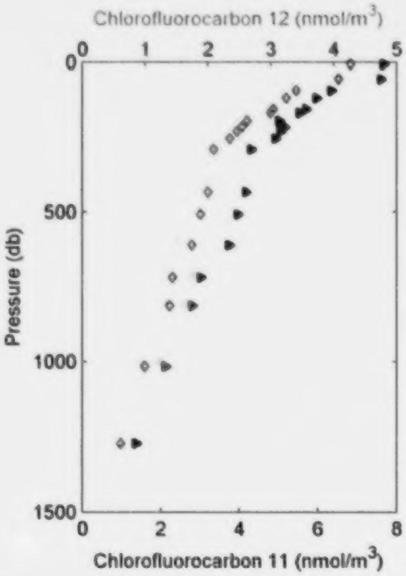


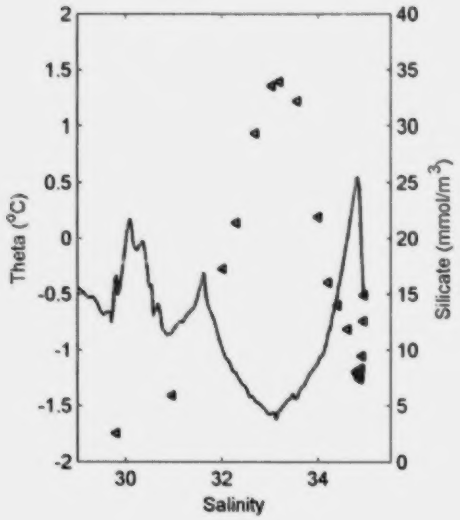
2005-04: Cast 45 Station CB27

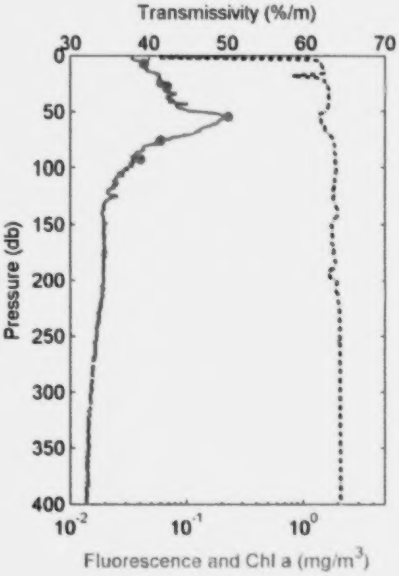


2005-04: Cast 46 Station CB29

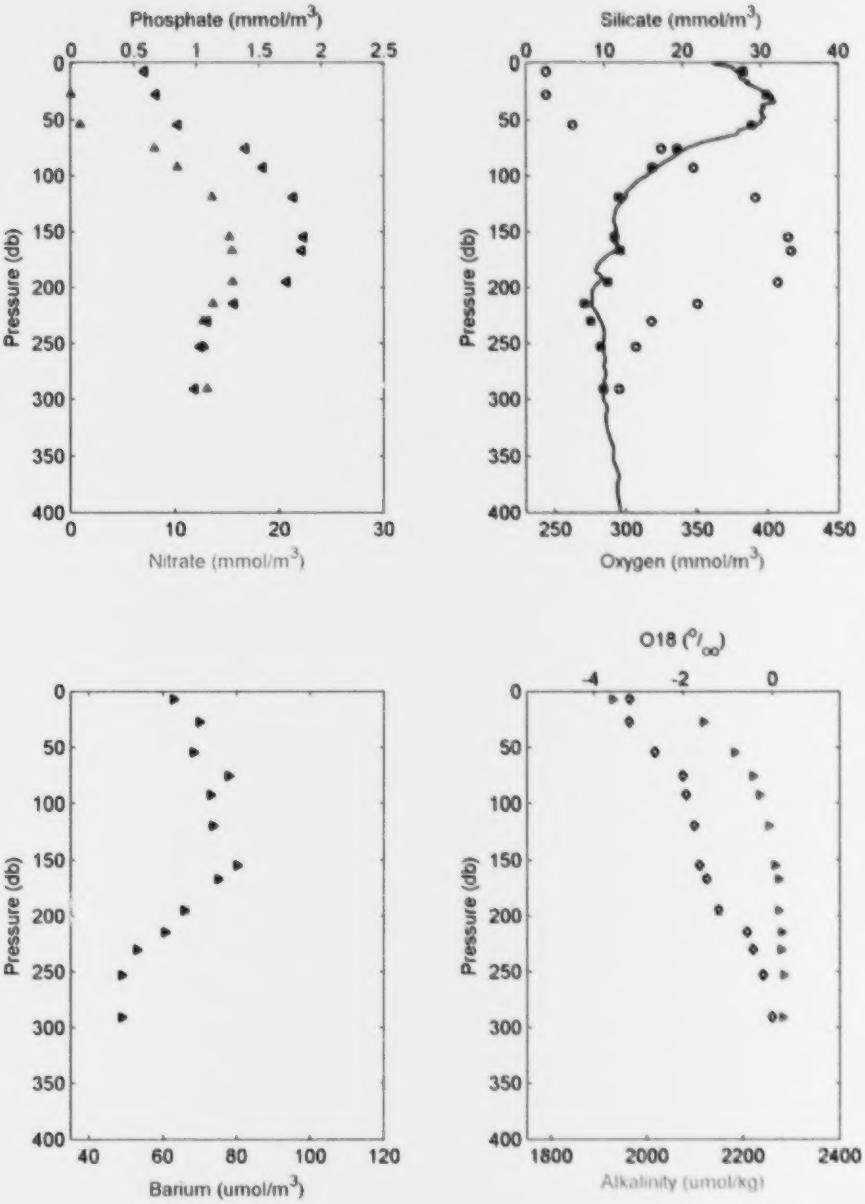




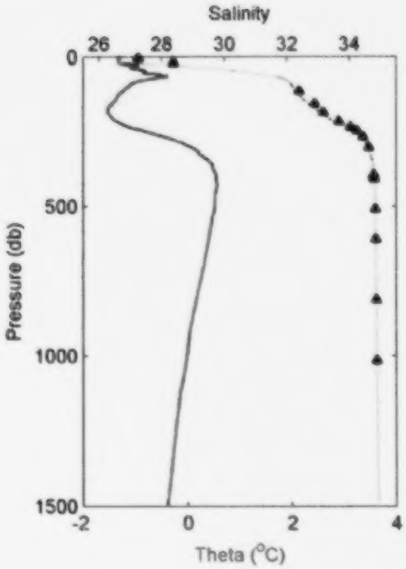


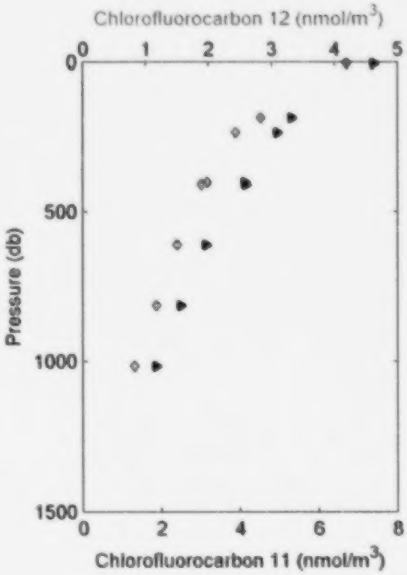


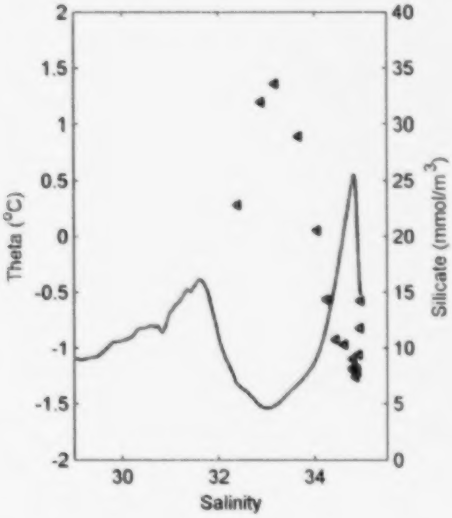
2005-04: Cast 46 Station CB29

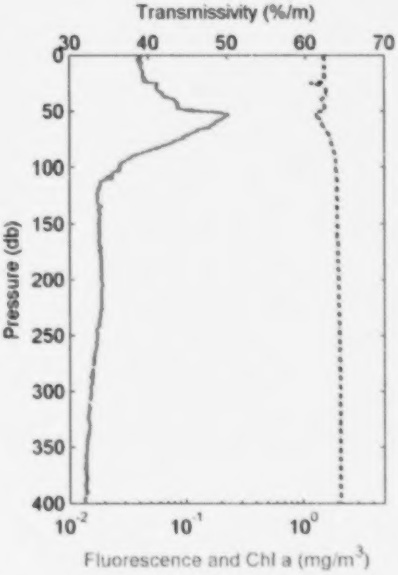


2005-04: Cast 47 Station CB23a

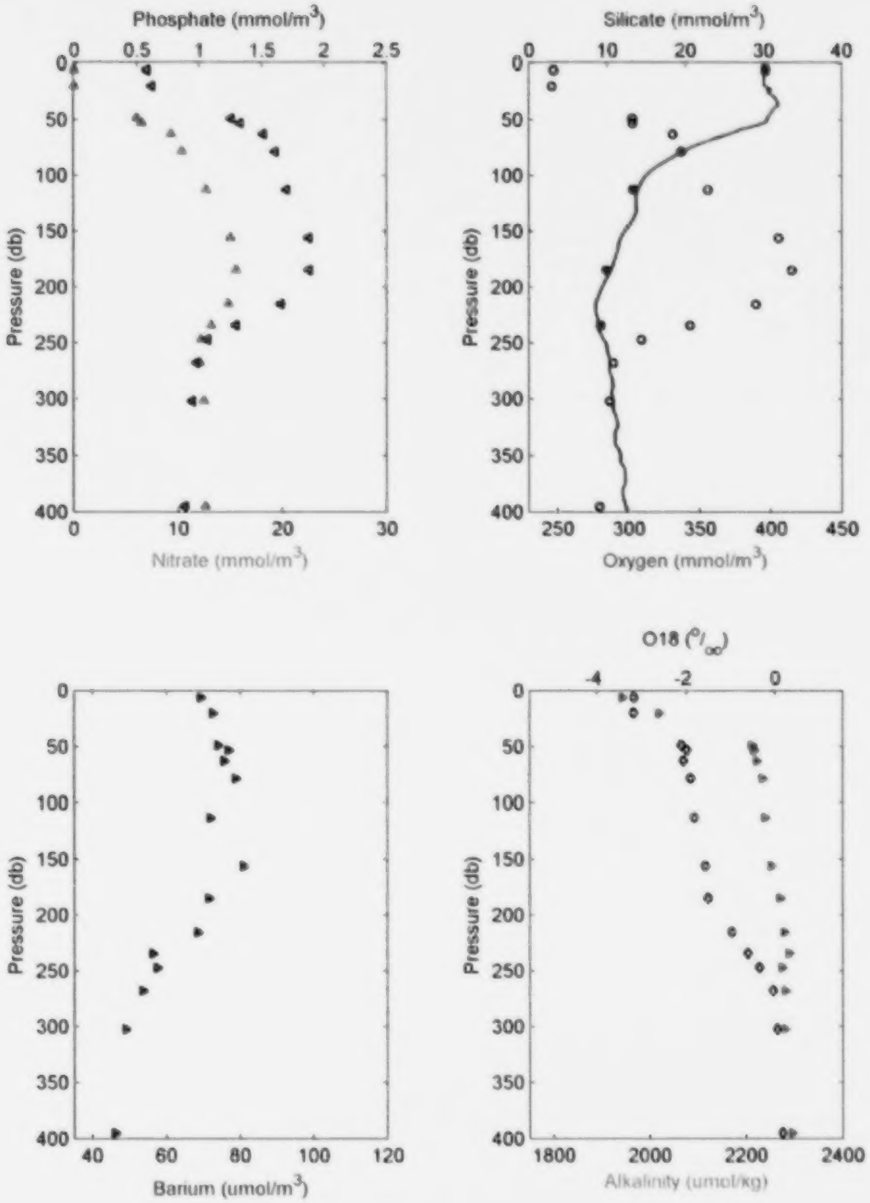




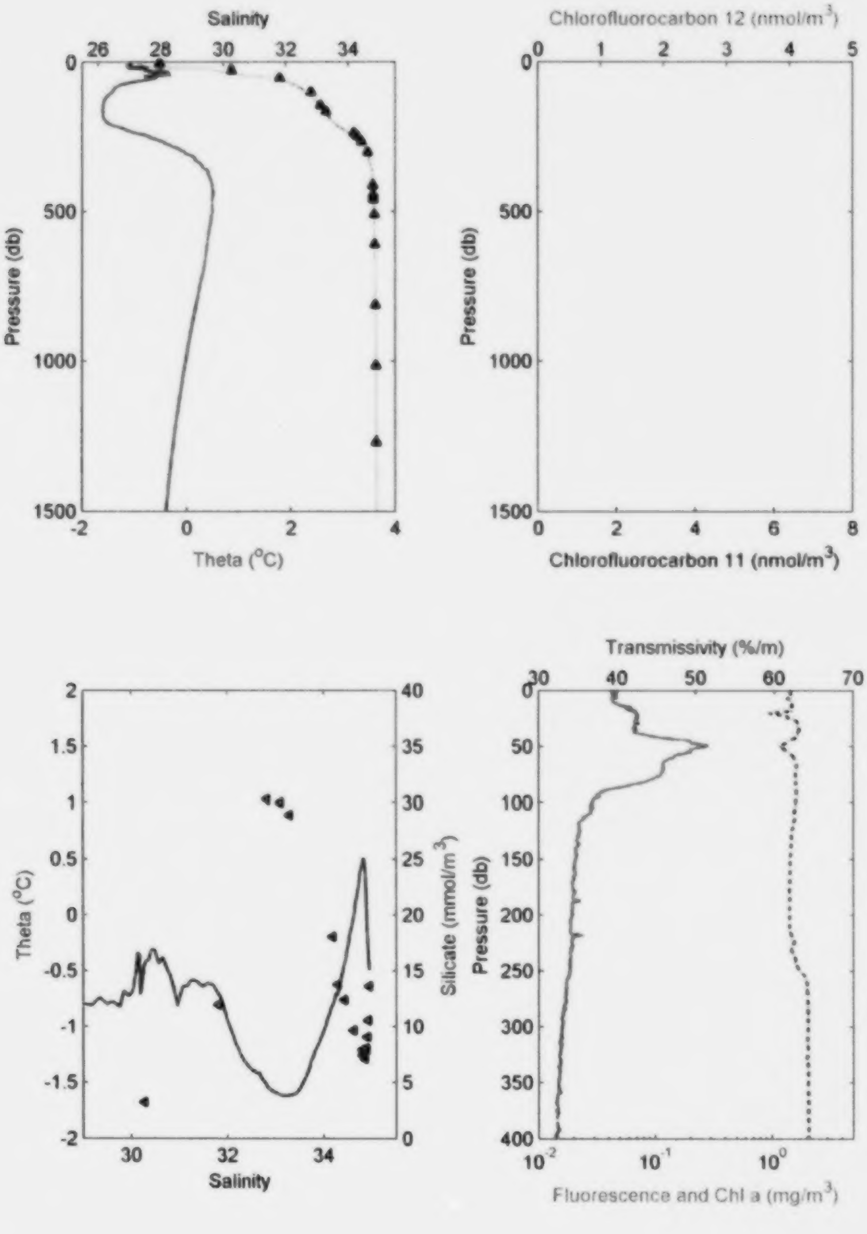




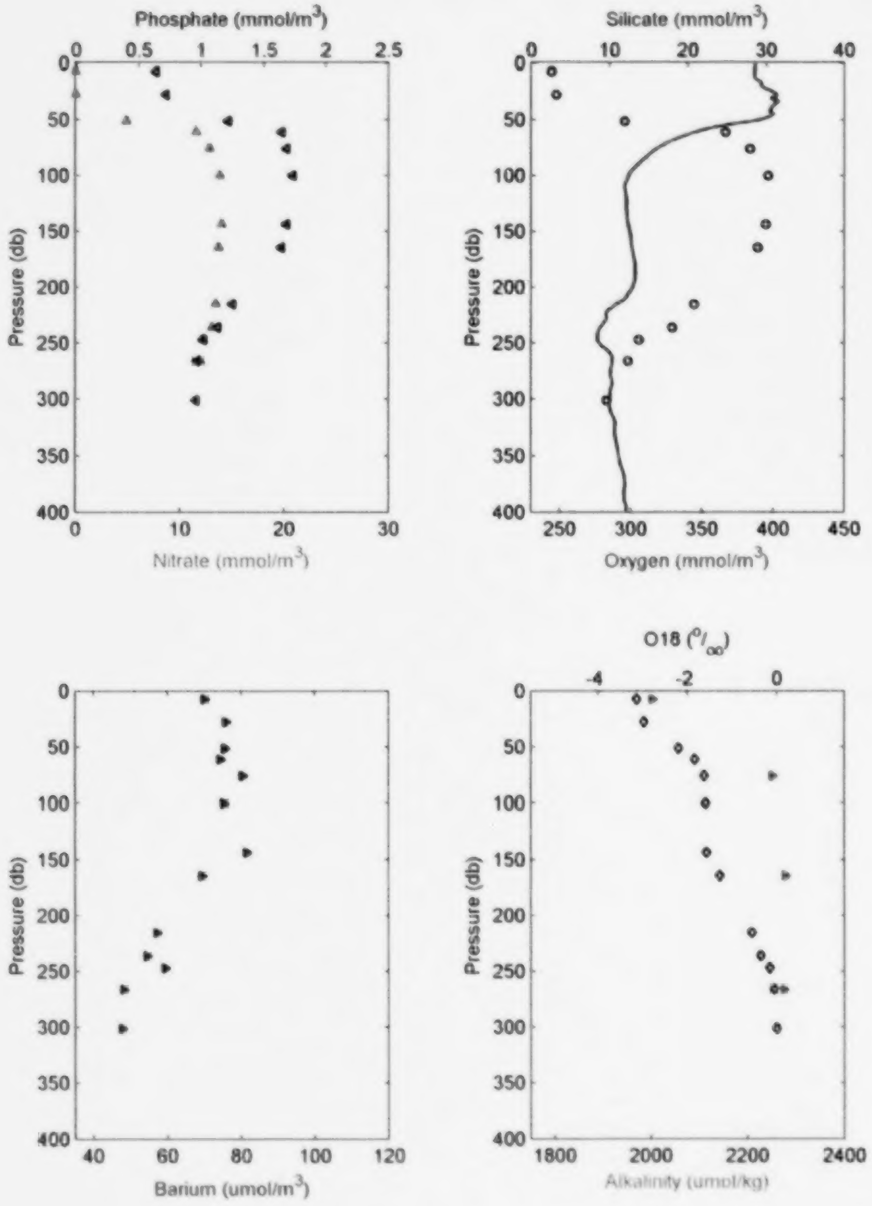
2005-04: Cast 47 Station CB23a



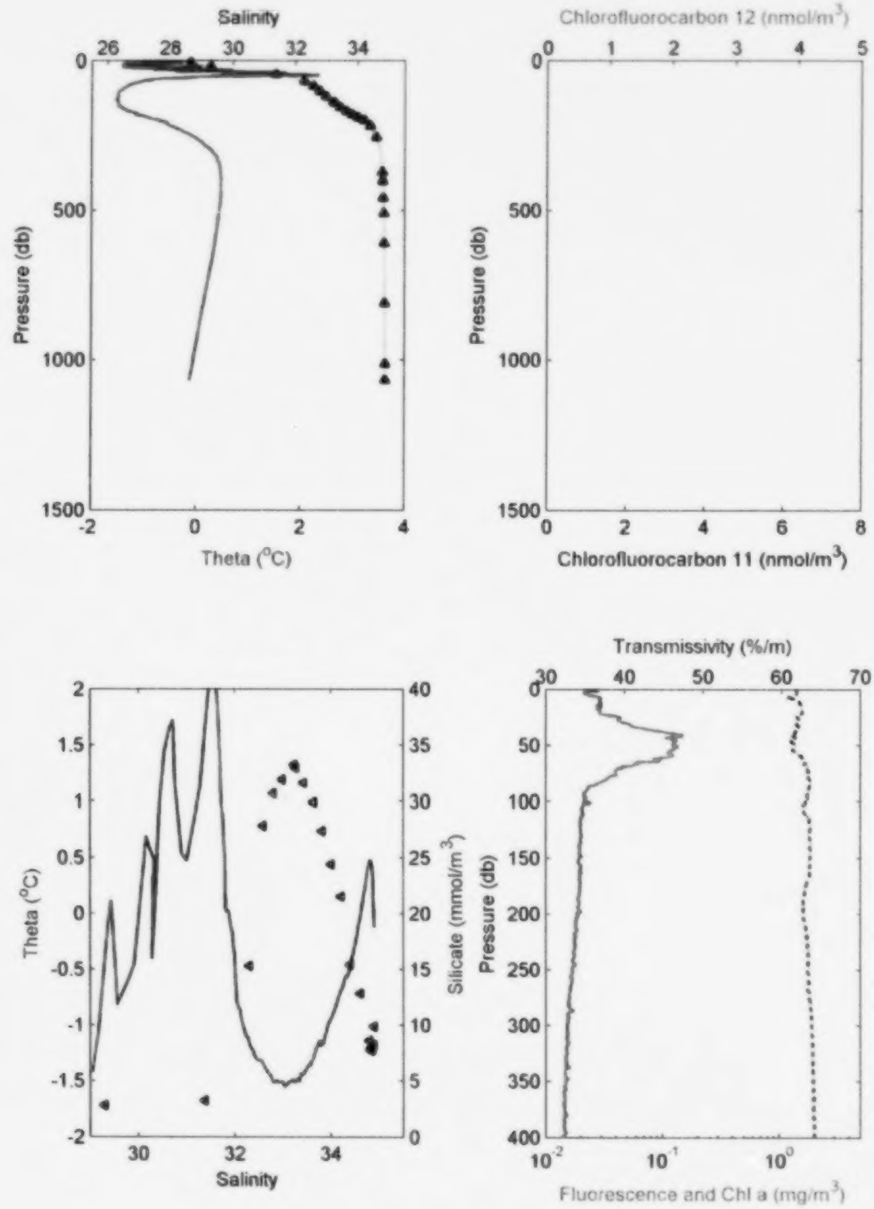
2005-04: Cast 48 Station CB31a



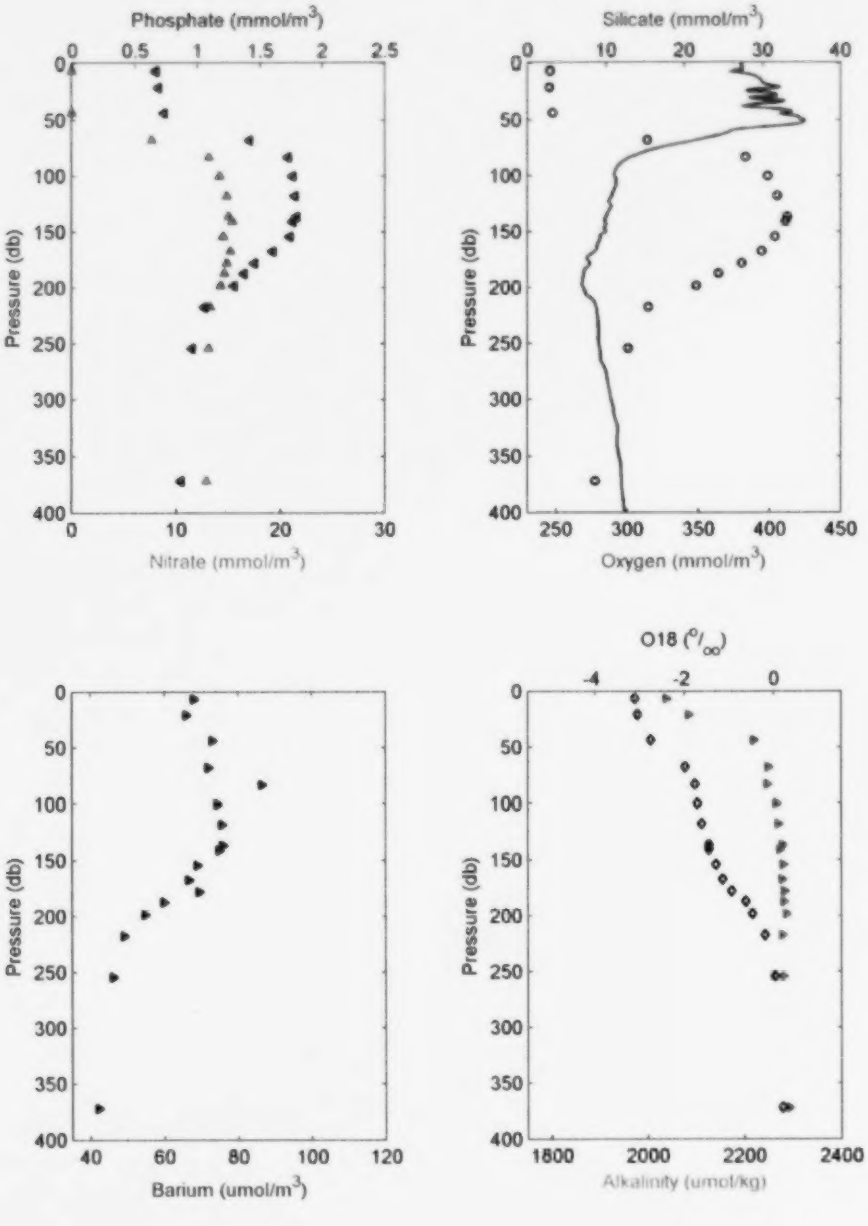
2005-04: Cast 48 Station CB31a



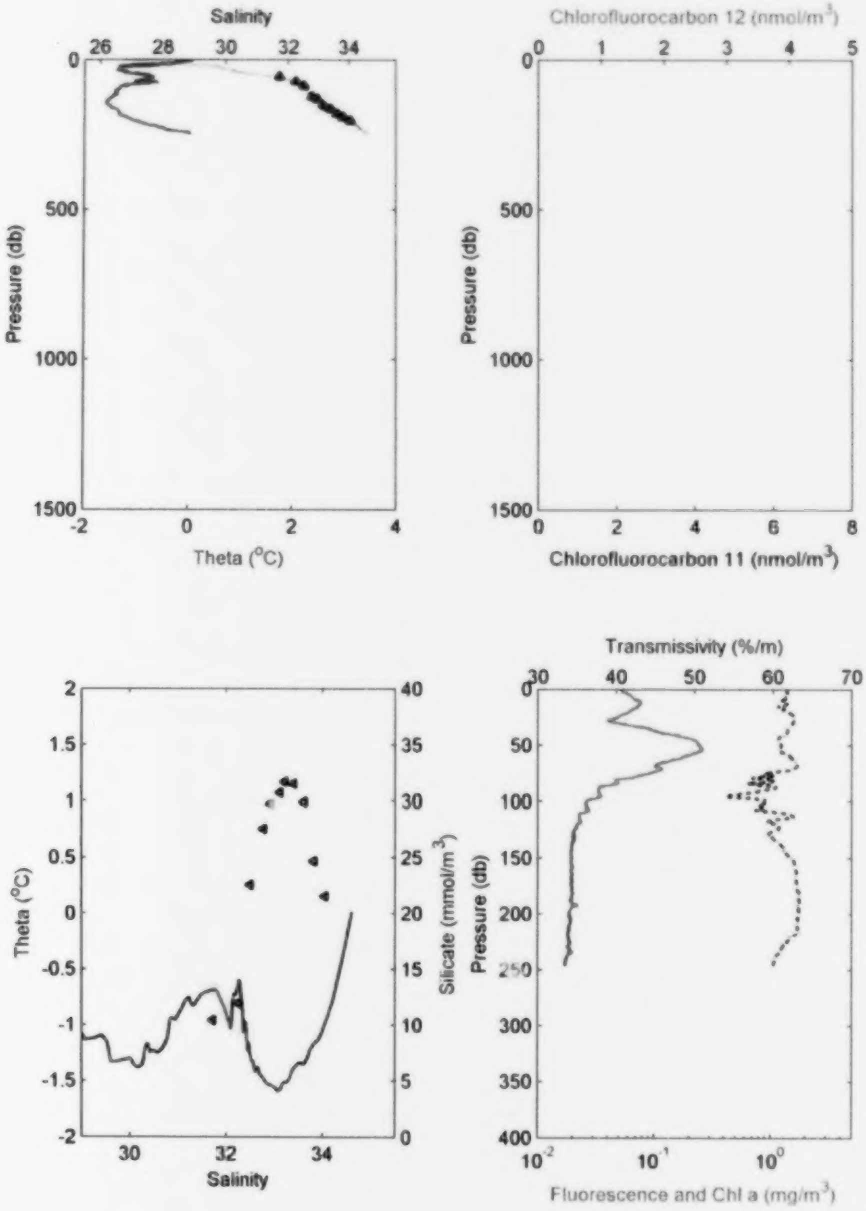
2005-04: Cast 49 Station CABOS



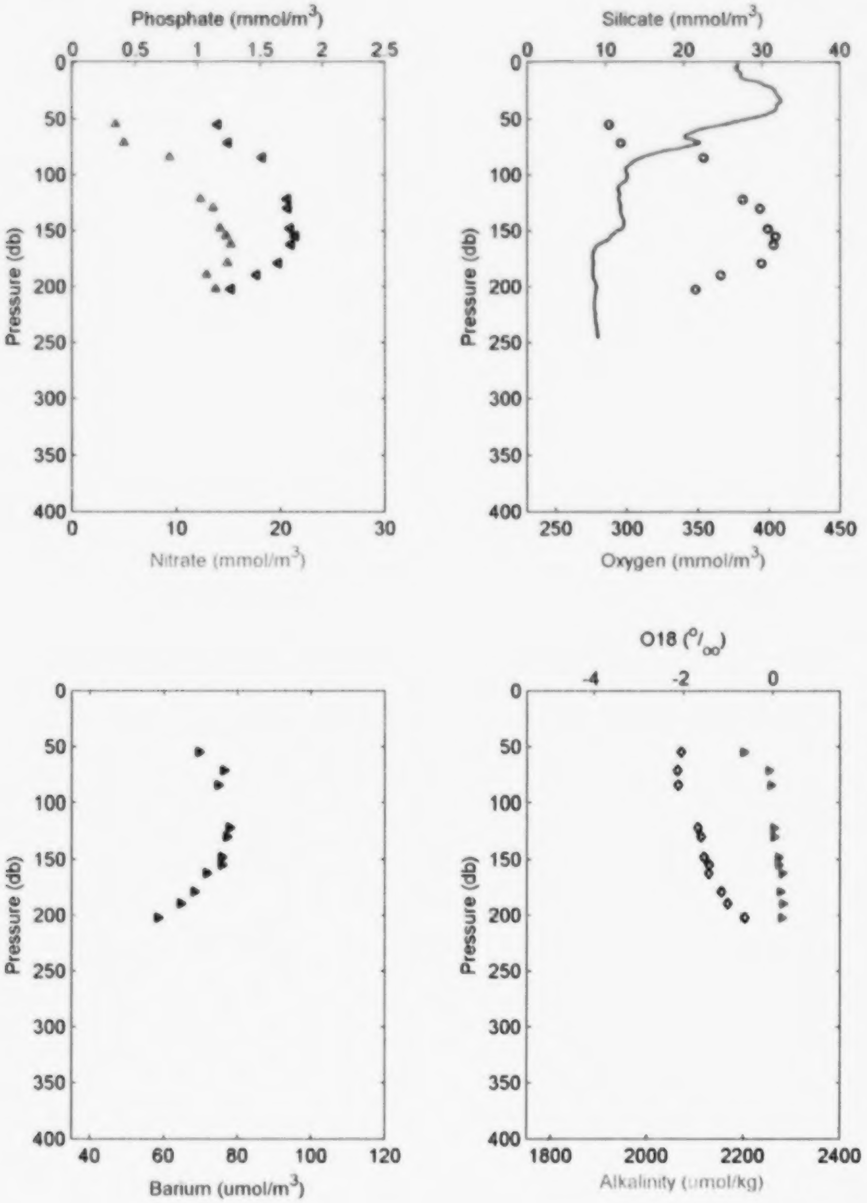
2005-04: Cast 49 Station CABOS



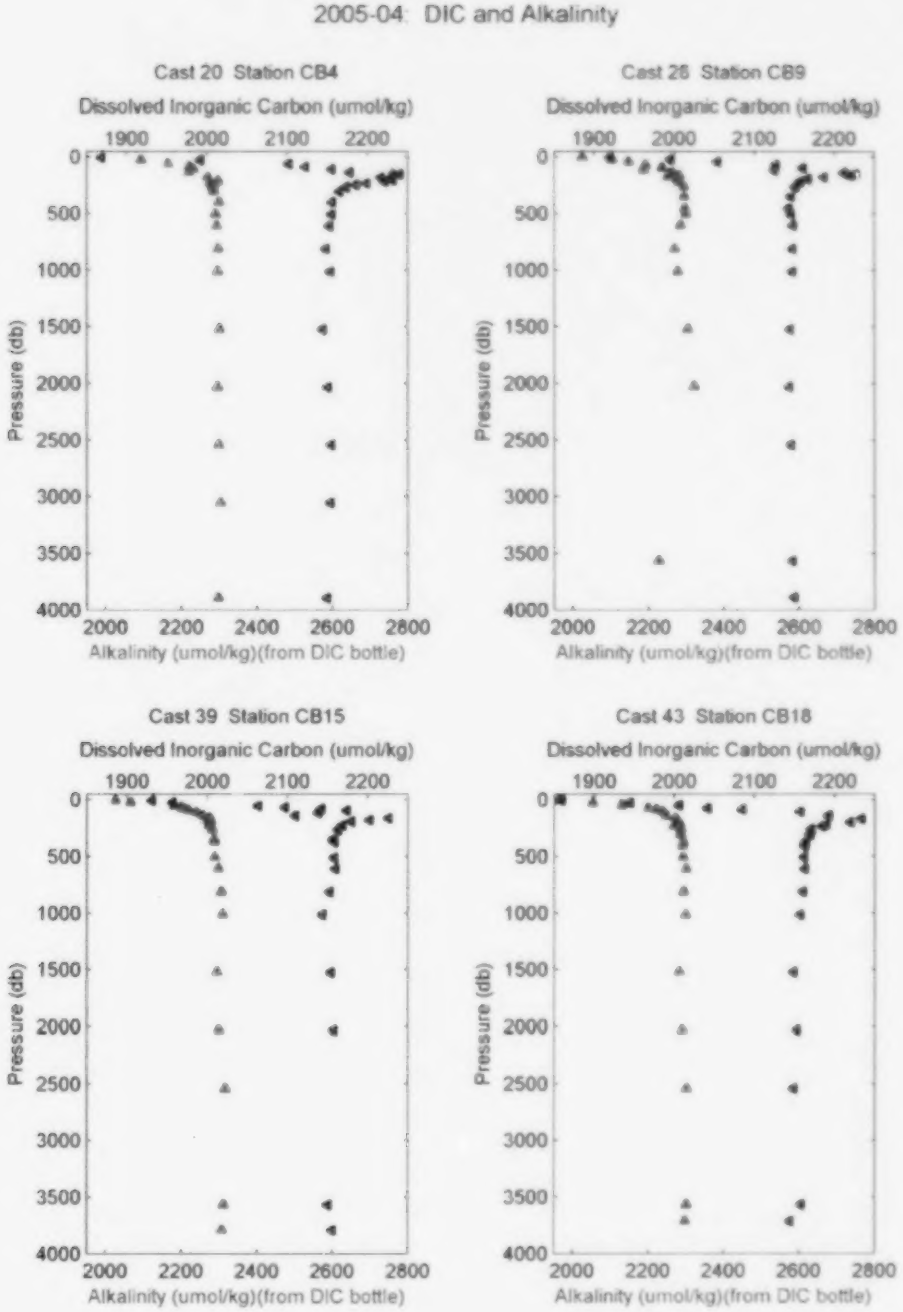
2005-04: Cast 50 Station CB1a



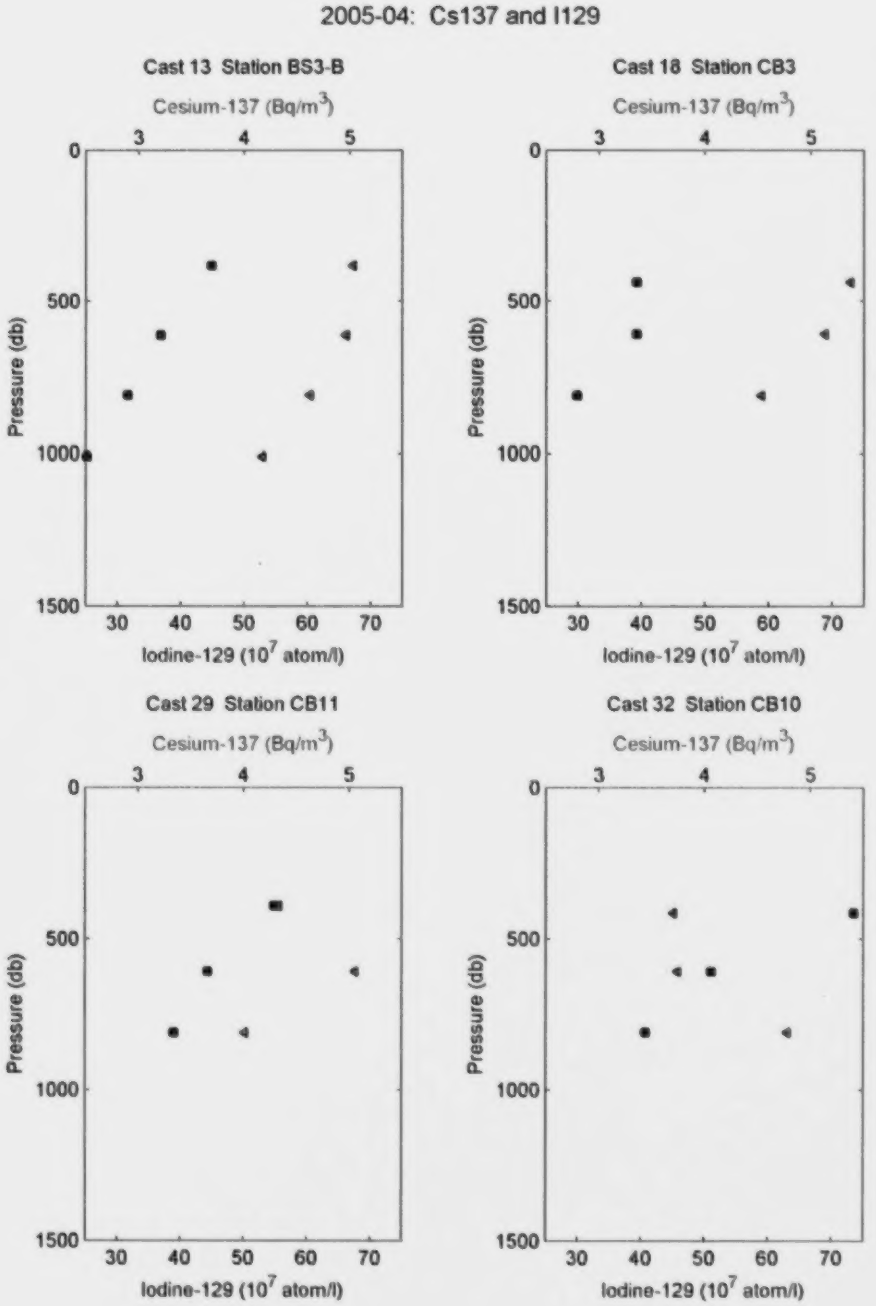
2005-04: Cast 50 Station CB1a



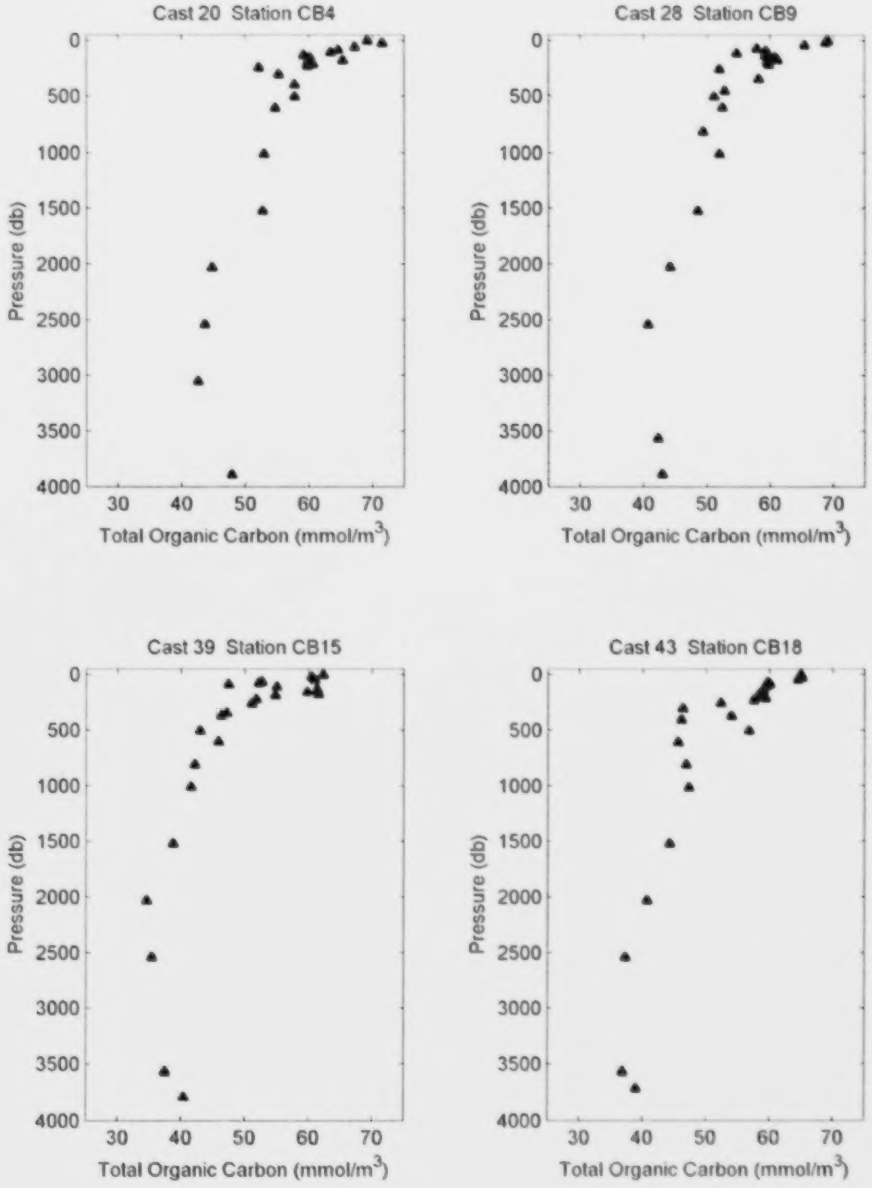
5.2 DIC and Alkalinity



5.3 ^{129}I and ^{137}Cs

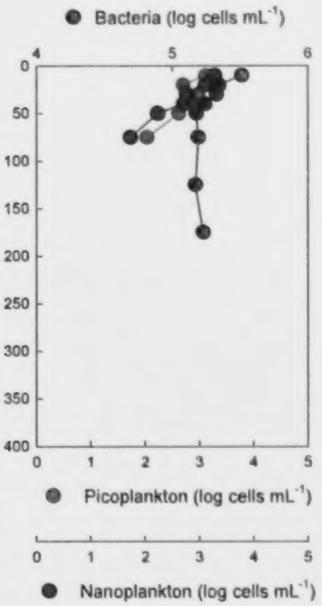

2005-04: Cs137 and I129

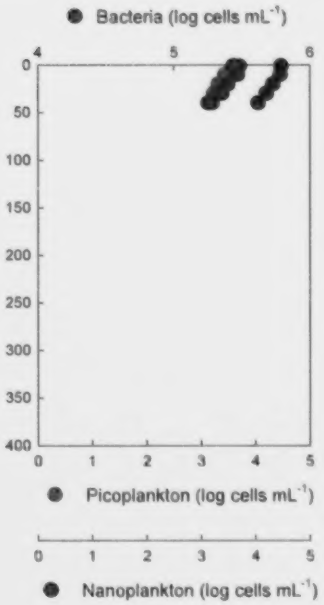
5.4 TOC

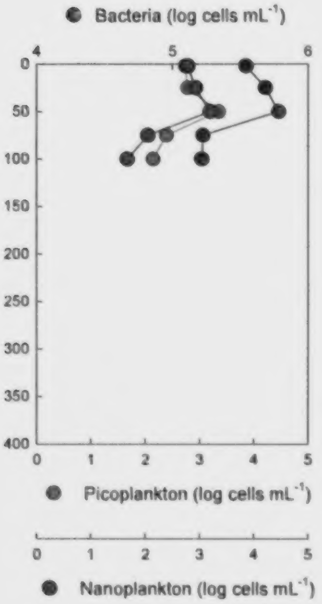

2005-04 TOC

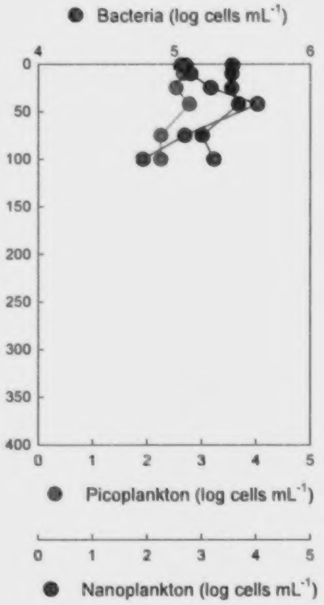
5.5 Bacteria

5.5.1 2005-04

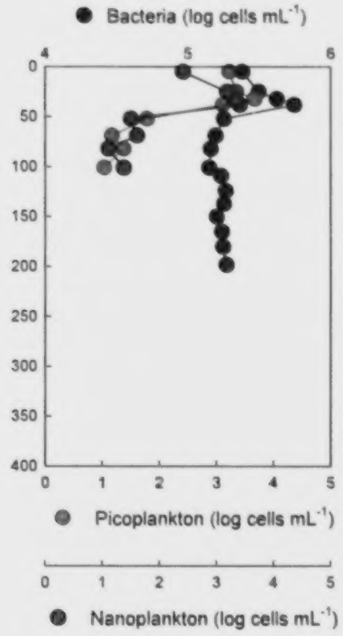

2005-04: Cast 1


2005-04: Cast 2

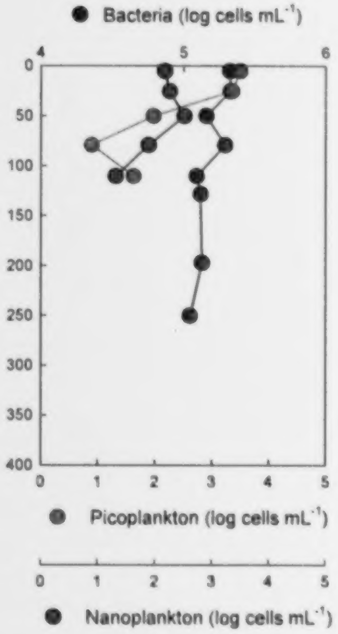

2005-04: Cast 3


2005-04: Cast 4

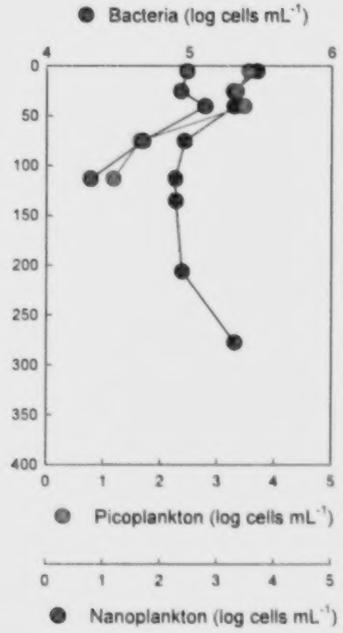
2005-04: Cast 5 Station AG5



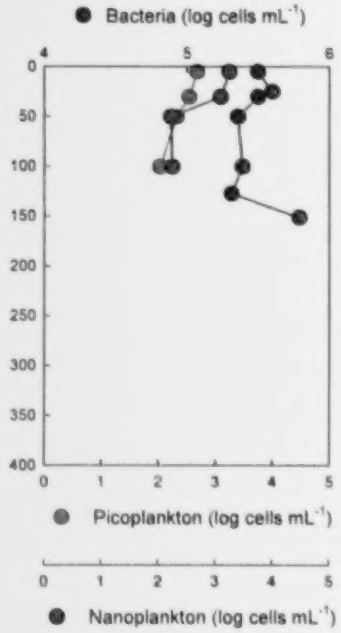
2005-04: Cast 6 Station CABOS



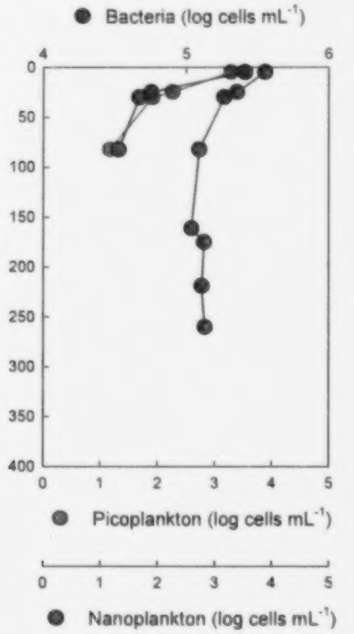
2005-04: Cast 10 Station CB-28A



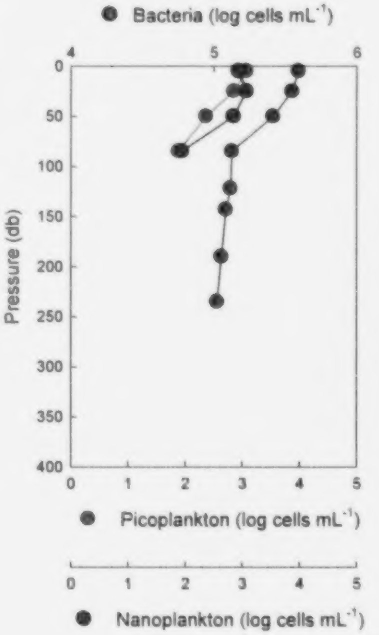
2005-04: Cast 12 Station BS3



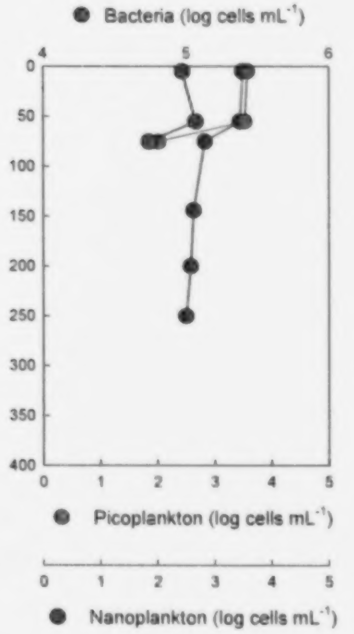
2005-04: Cast 14 Station BS3B



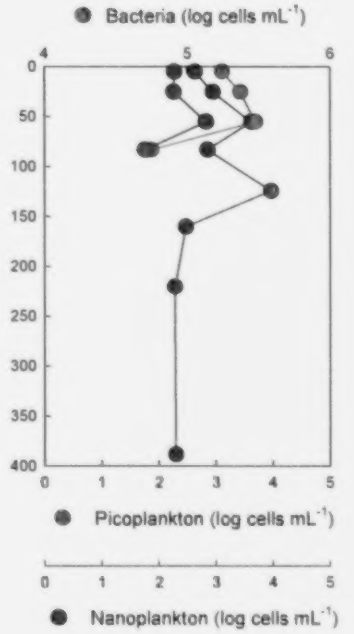
2005-04: Cast 15 Station BS3C



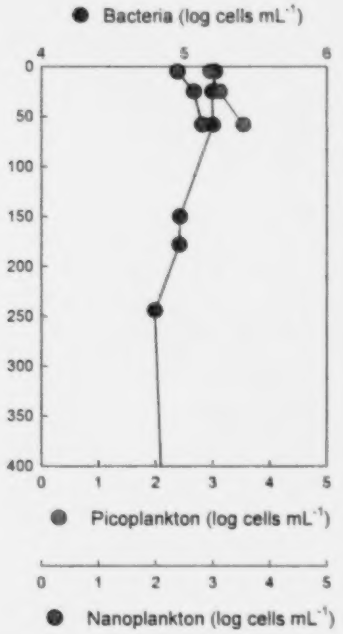
2005-04: Cast 16 Station BS3D



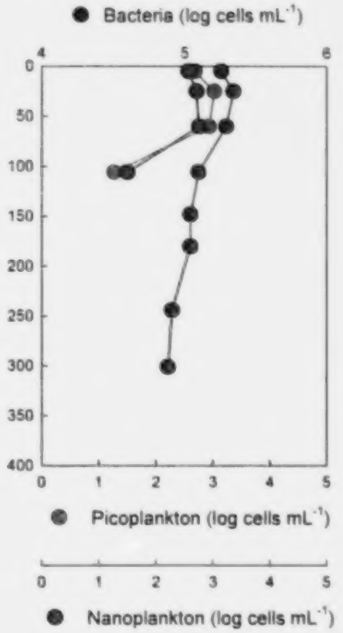
2005-04: Cast 17 Station CB-02



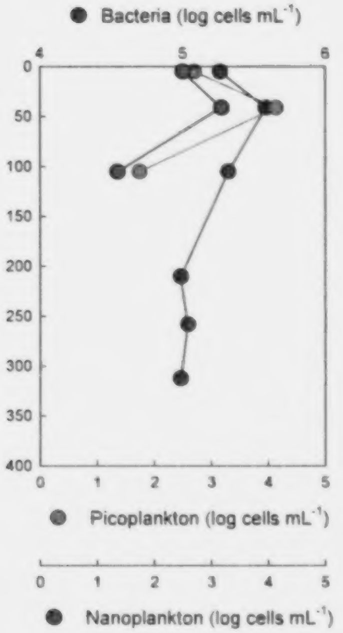
2005-04: Cast 19 Station CB-03



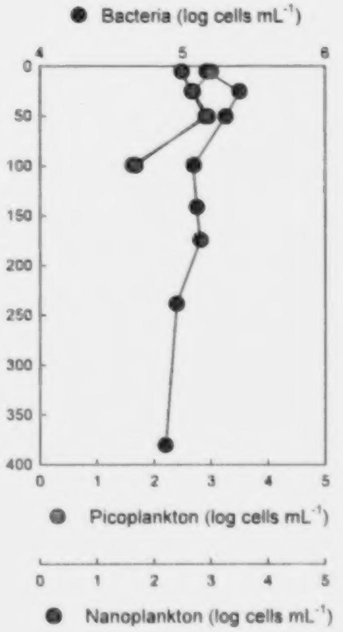
2005-04: Cast 20 Station CB-04

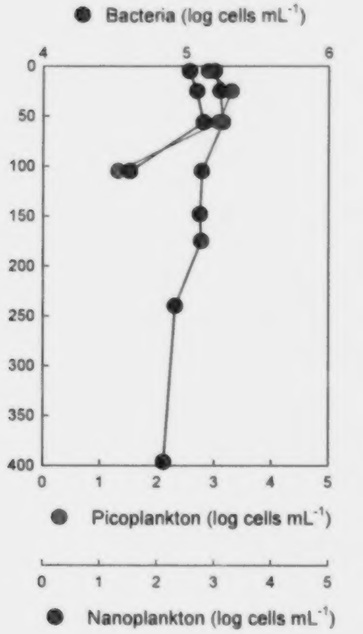


2005-04: Cast 21 Station CB-05

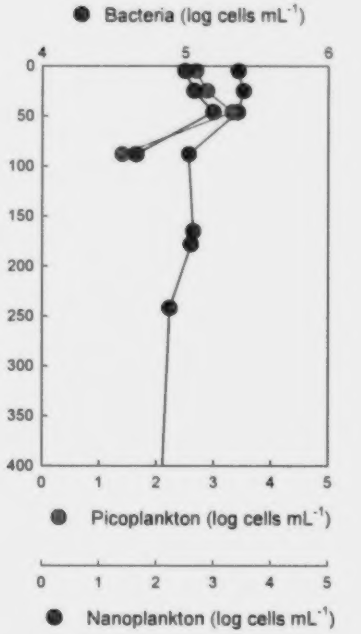


2005-04: Cast 22 Station CB-05A

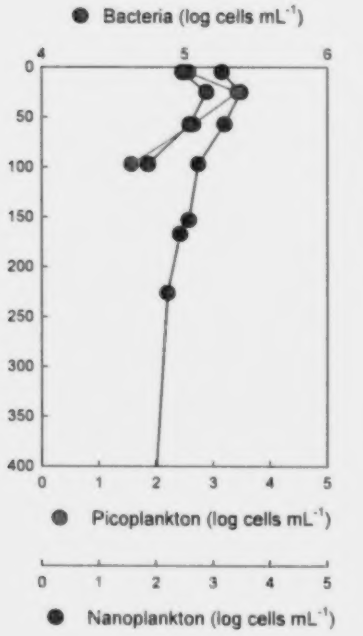




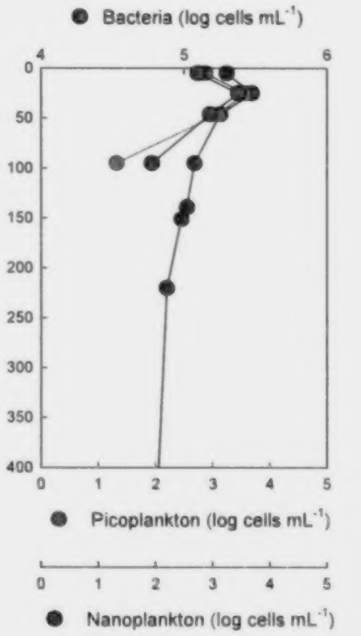
2005-04: Cast 24 Station CB-06



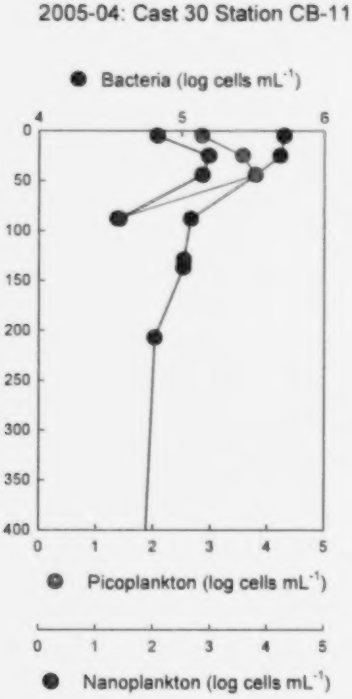
2005-04: Cast 26 Station CB-07

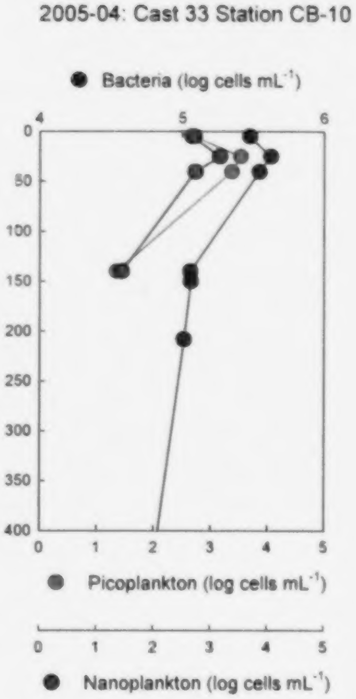


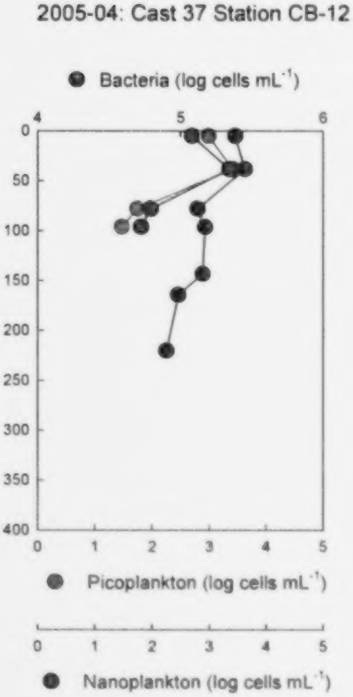
2005-04: Cast 27 Station CB-08

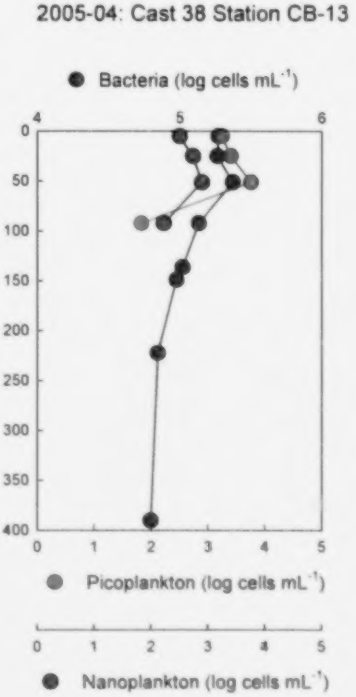


2005-04: Cast 28 Station CB-09

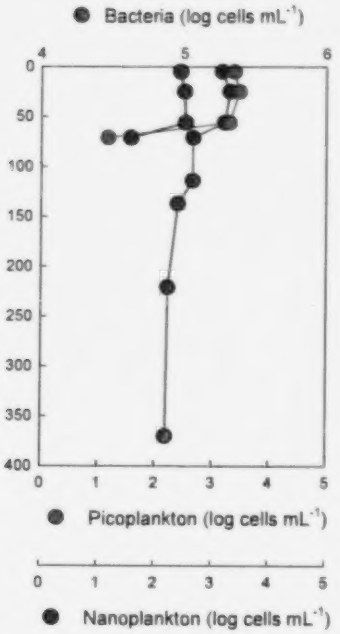

2005-04: Cast 30 Station CB-11
● Bacteria (log cells mL^{-1})
4
5
6
0
50
100
150
200
250
300
350
400
0
1
2
3
4
5
● Picoplankton (log cells mL^{-1})
0
1
2
3
4
5
● Nanoplankton (log cells mL^{-1})


2005-04: Cast 33 Station CB-10
● Bacteria (log cells mL^{-1})
4
5
6
0
50
100
150
200
250
300
350
400
0
1
2
3
4
5
● Picoplankton (log cells mL^{-1})
0
1
2
3
4
5
● Nanoplankton (log cells mL^{-1})

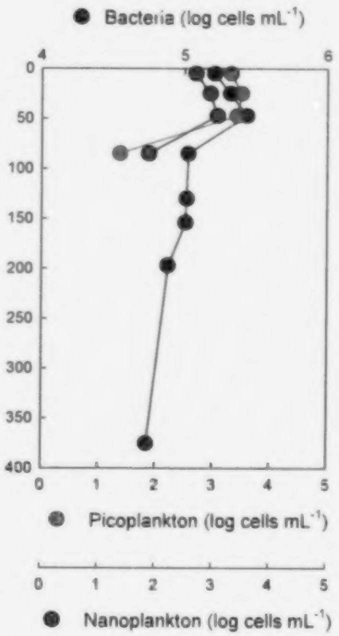

2005-04: Cast 37 Station CB-12
● Bacteria (log cells mL^{-1})
4
5
6
0
50
100
150
200
250
300
350
400
0
1
2
3
4
5
● Picoplankton (log cells mL^{-1})
0
1
2
3
4
5
● Nanoplankton (log cells mL^{-1})


2005-04: Cast 38 Station CB-13
● Bacteria (log cells mL^{-1})
4
5
6
0
50
100
150
200
250
300
350
400
0
1
2
3
4
5
● Picoplankton (log cells mL^{-1})
0
1
2
3
4
5
● Nanoplankton (log cells mL^{-1})

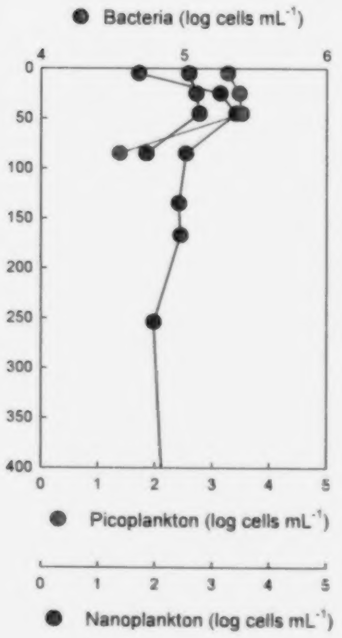
2005-04: Cast 39 Station CB-15



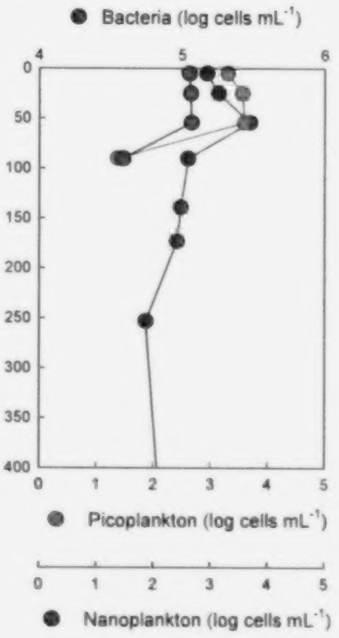
2005-04: Cast 42 Station CB-17



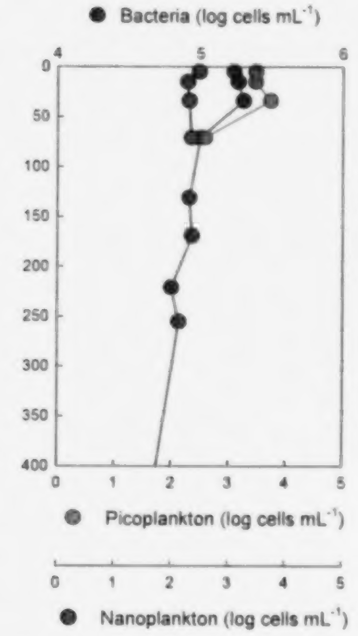
2005-04: Cast 43 Station CB-18



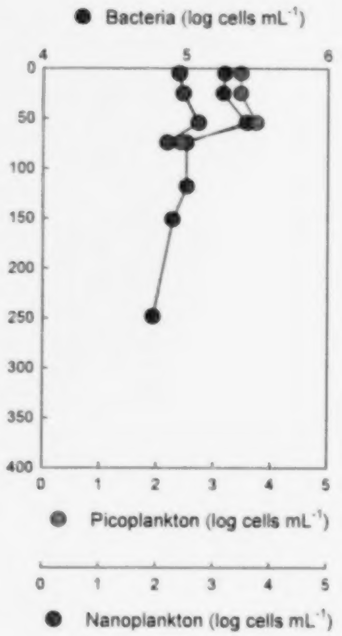
2005-04: Cast 44 Station CB-21



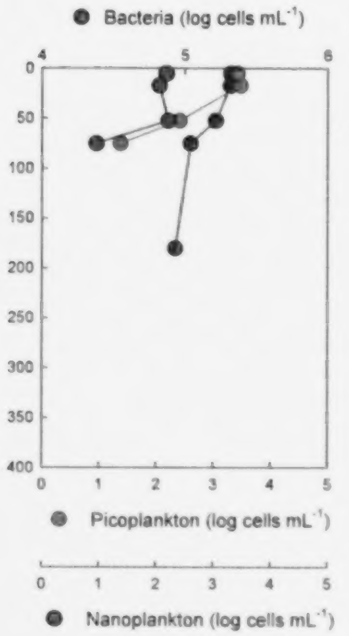
2005-04: Cast 45 Station CB-27



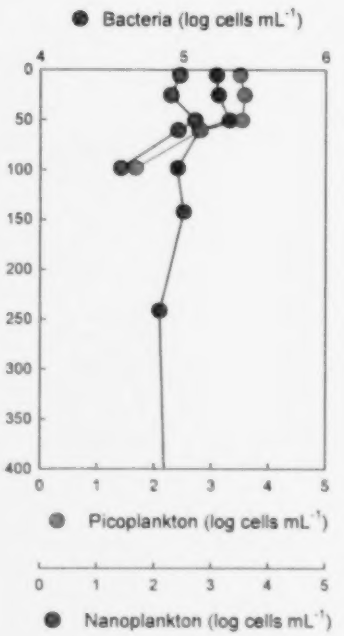
2005-04: Cast 46 Station CB-29



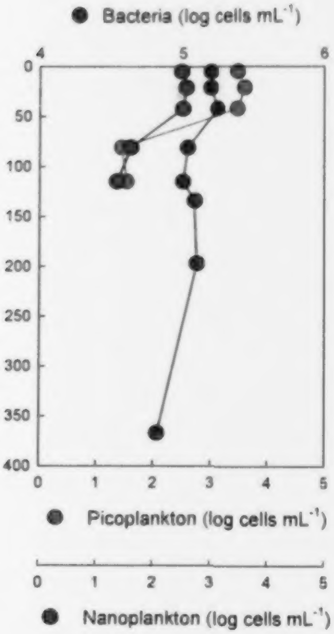
2005-04: Cast 47 Station CB-23a



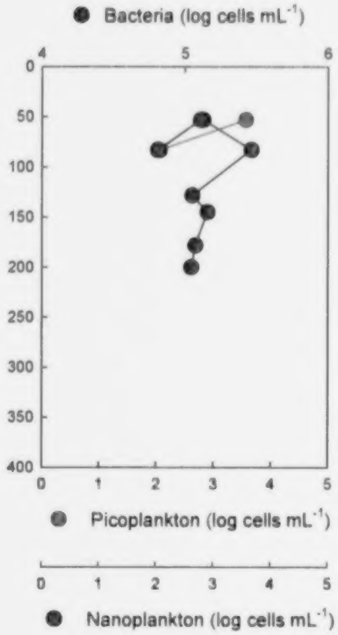
2005-04: Cast 48 Station CB-31a



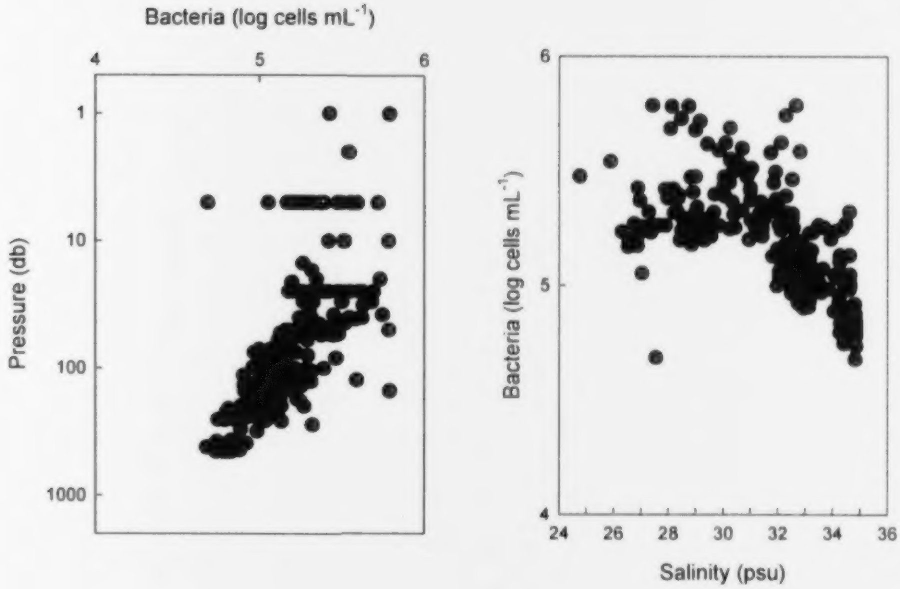
2005-04: Cast 49 Station CABOS



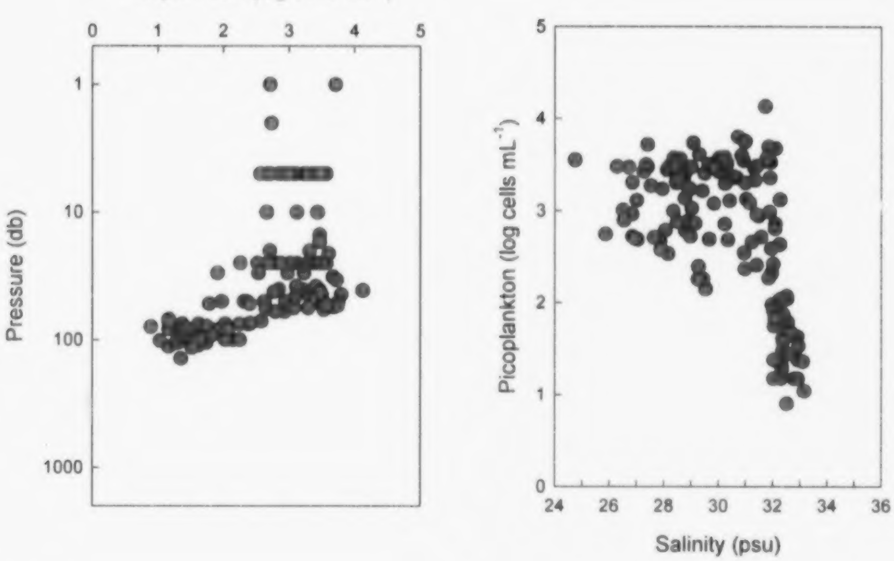
2005-04: Cast 50 Station CB-01a



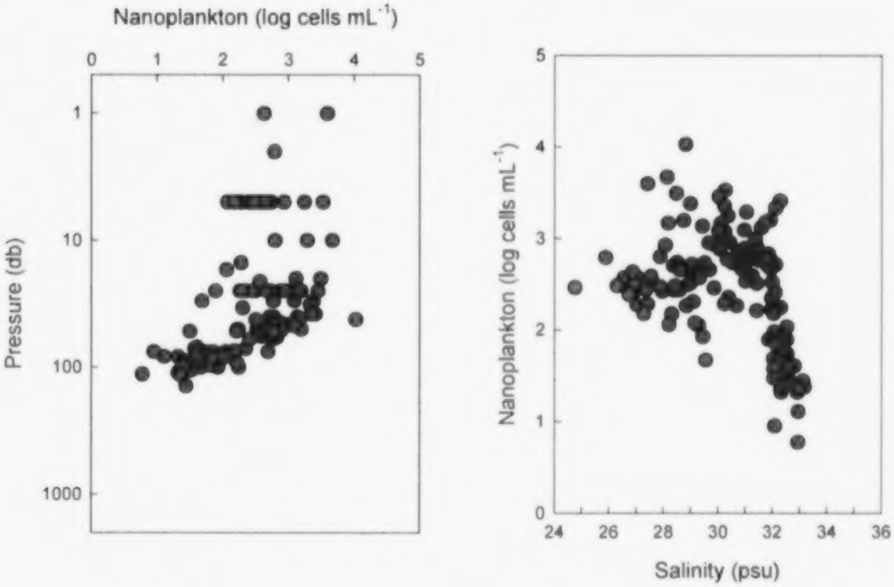
2005-04



2005-04

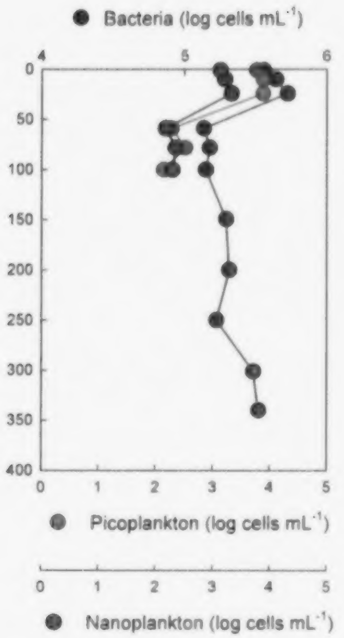


2005-04

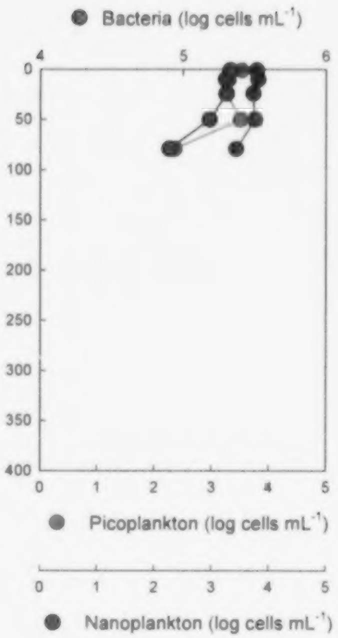


5.5.2 2004-16

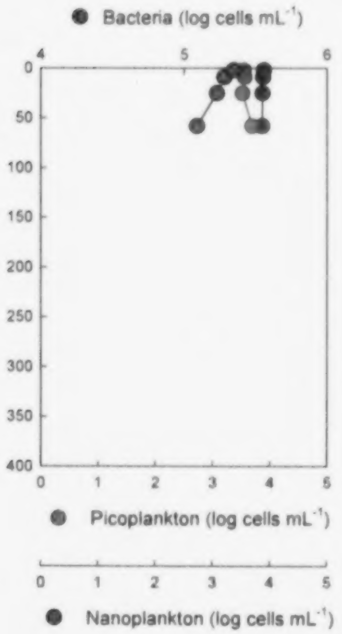
2004-16: Cast 2



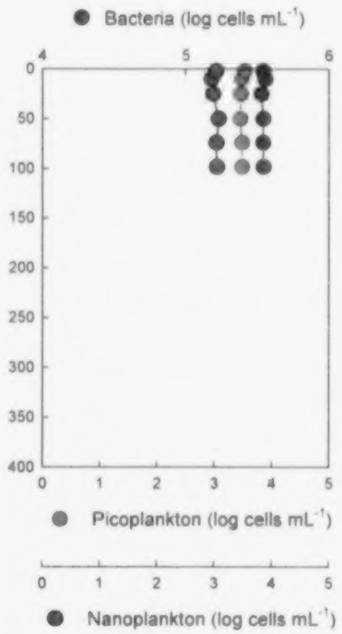
2004-16: Cast 3



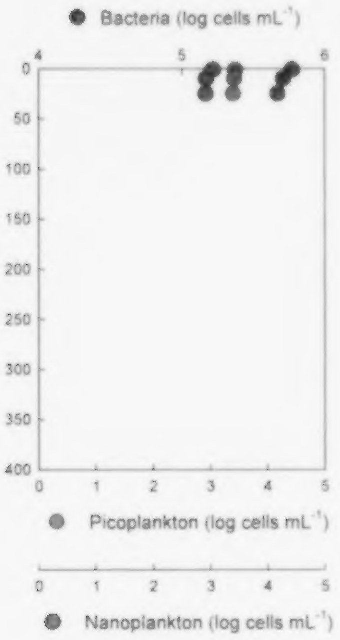
2004-16: Cast 4



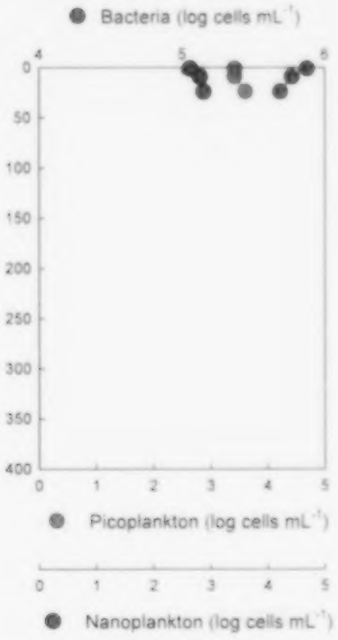
2004-16: Cast 5



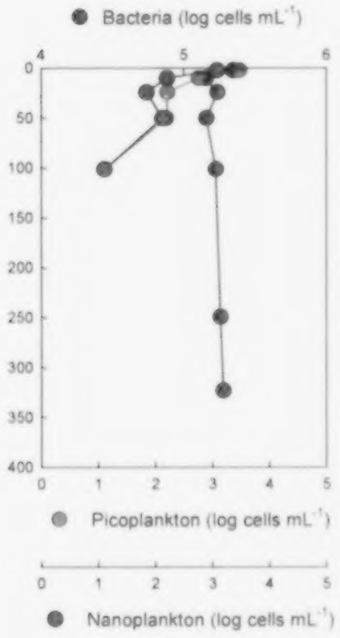
2004-16: Cast 6



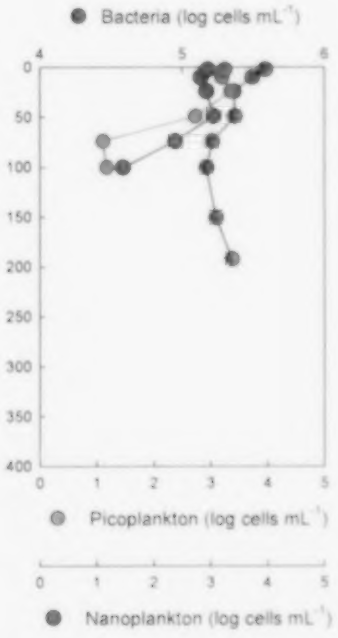
2004-16: Cast 7



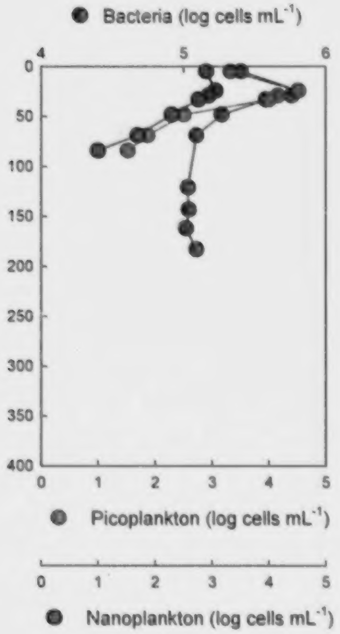
2004-16: Cast 10



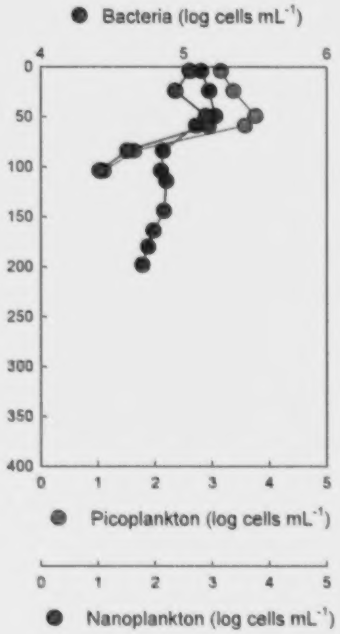
2004-16: Cast 14



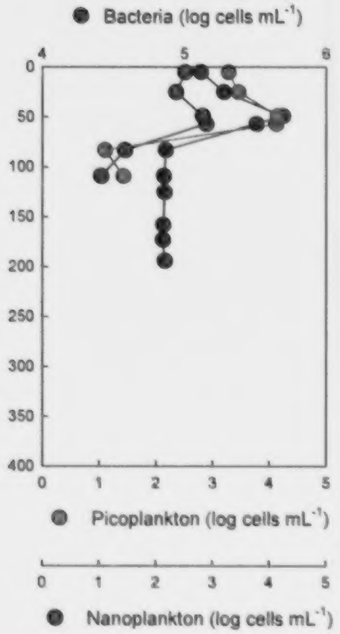
2004-16: Cast 15



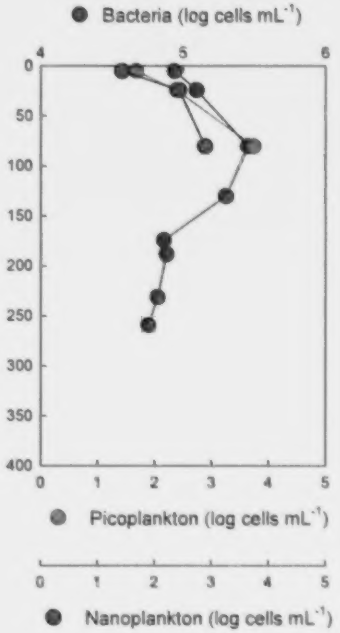
2004-16: Cast 16 CB-01



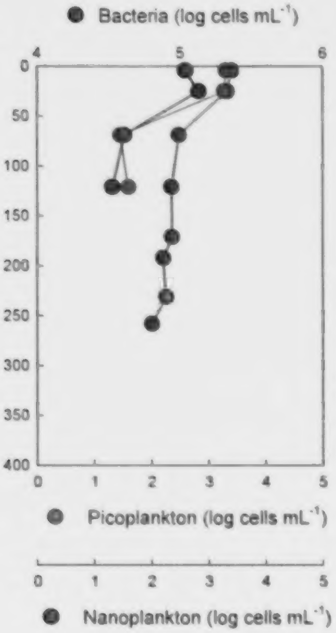
2004-16: Cast 17 CB-02



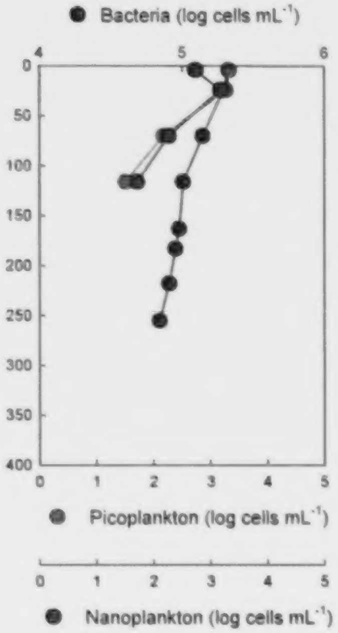
2004-16: Cast 18 CB-03



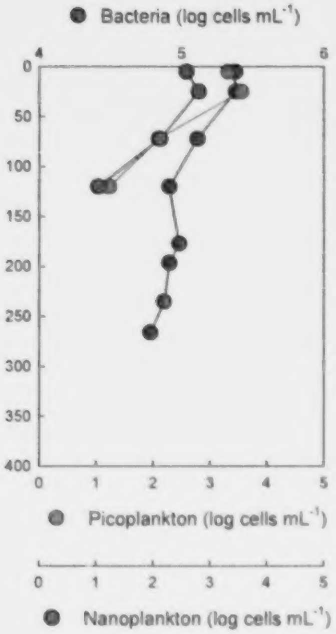
2004-16: Cast 19 CB-04



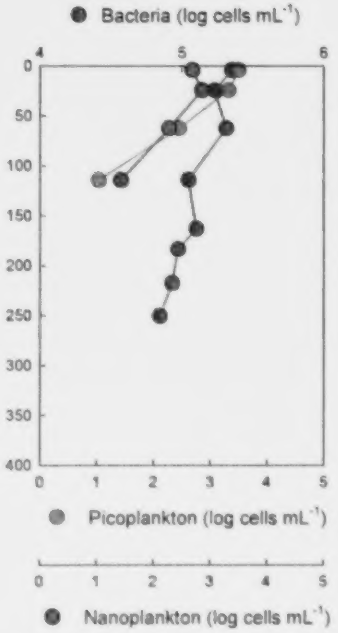
2004-16: Cast 20 CB-05



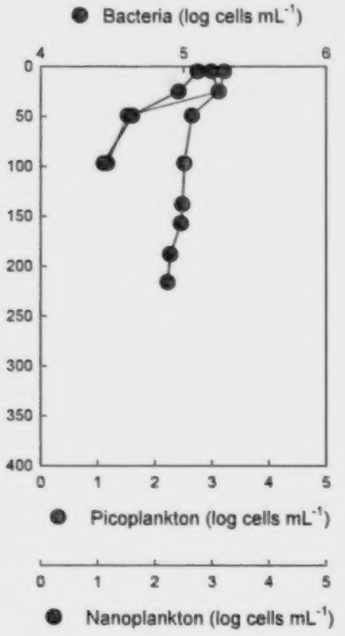
2004-16: Cast 21 CB-06



2004-16: Cast 22 CB-07



2004-16: Cast 23 CB-08



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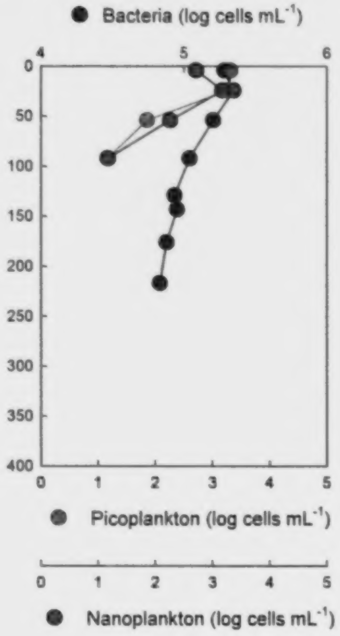
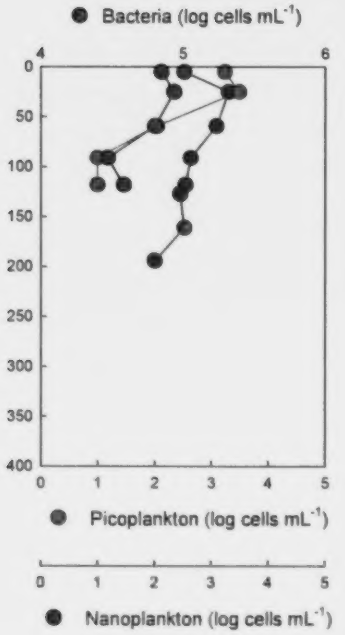
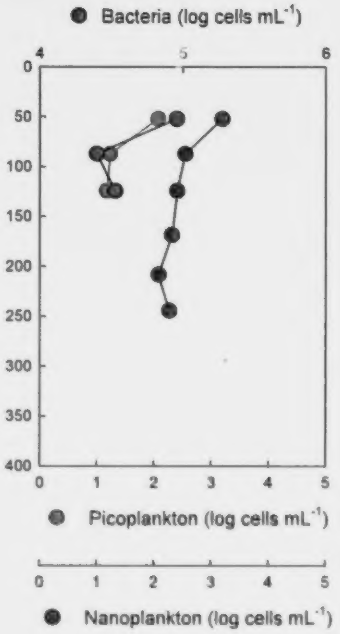


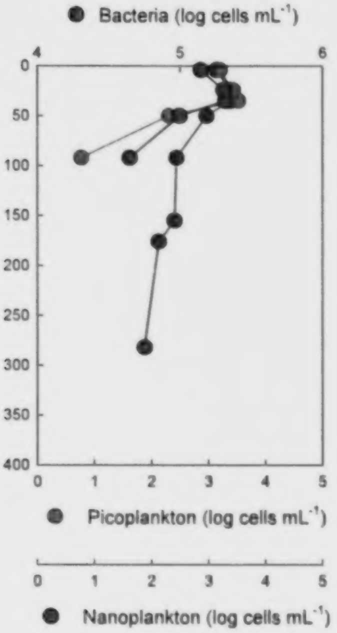
2004-16: Cast 26 CB-10



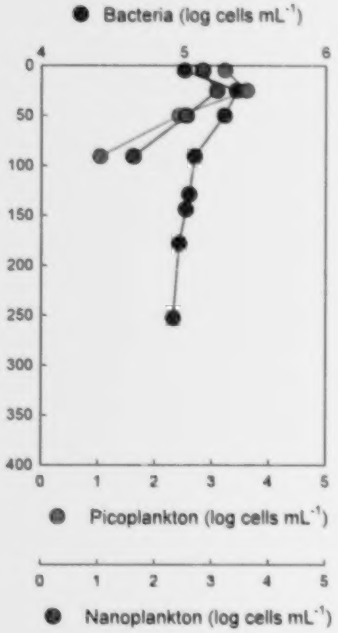
2004-16: Cast 28 CB-11(2)



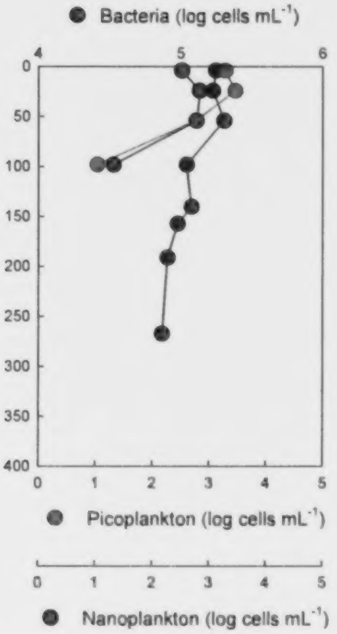
2004-16: Cast 29 CB-12



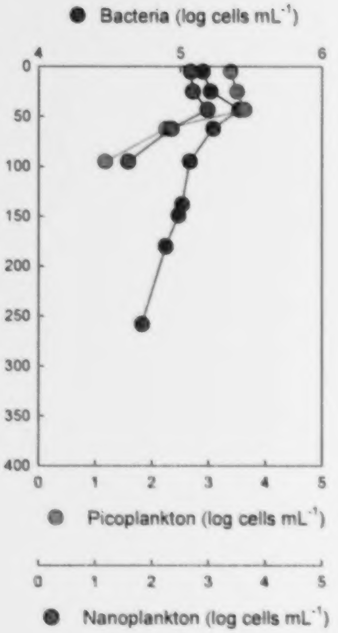
2004-16: Cast 30 CB-13



2004-16: Cast 31 CB-14



2004-16: Cast 32 CB-15



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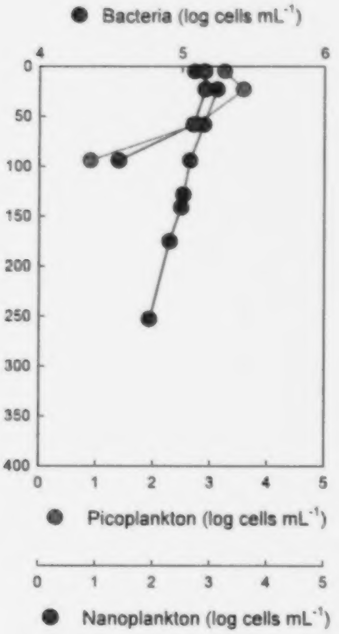
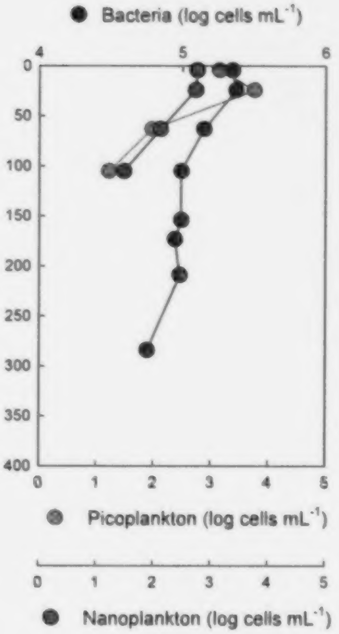
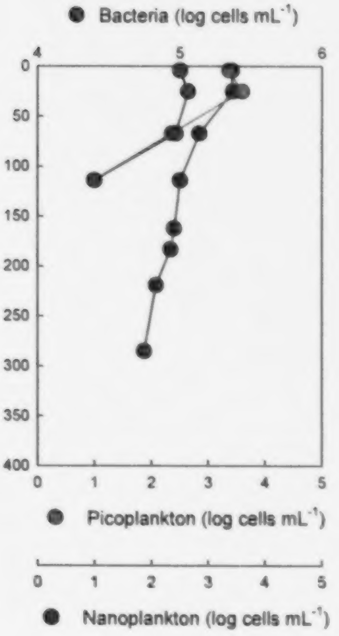


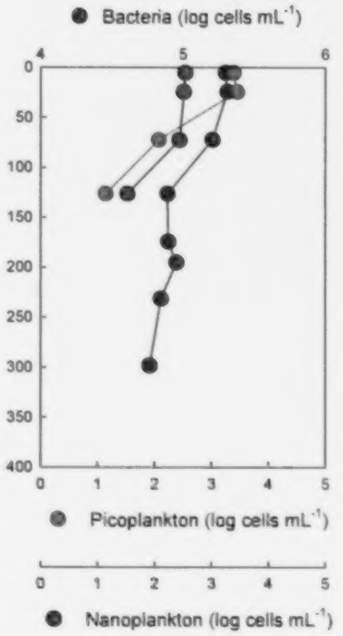
2004-16: Cast 34 CB-17



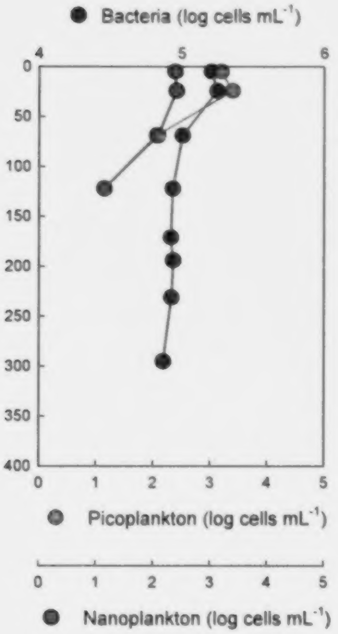
2004-16: Cast 35 CB-18



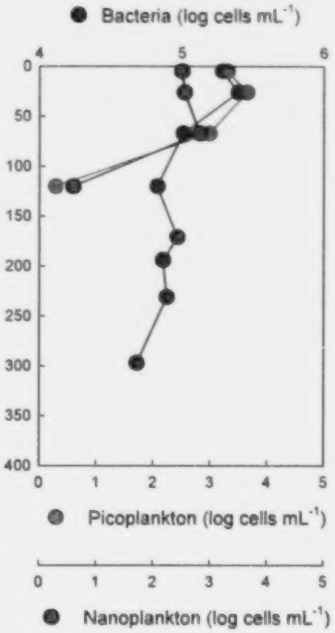
2004-16: Cast 36 CB-19



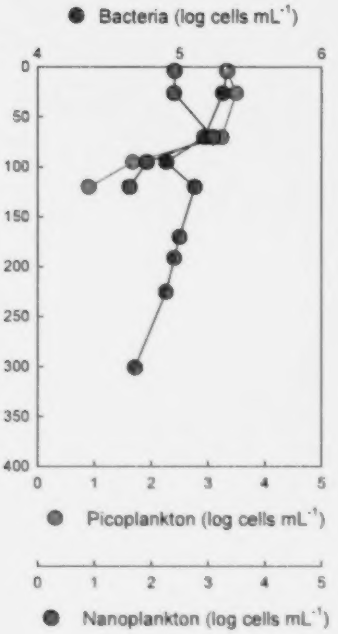
2004-16: Cast 37 CB-20



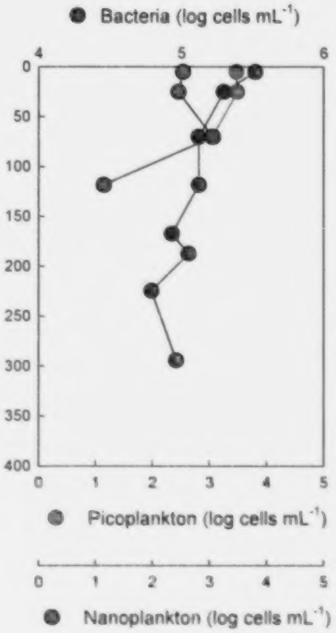
2004-16: Cast 38 CB-21



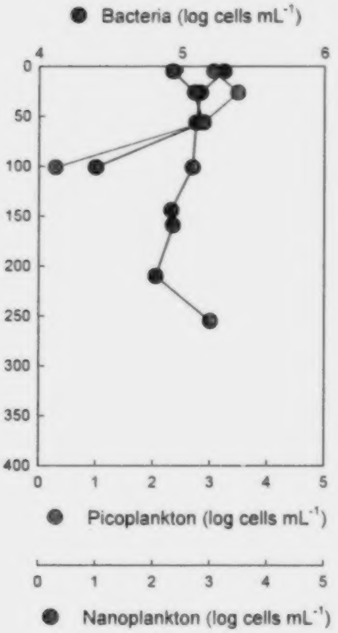
2004-16: Cast 39 CB-22



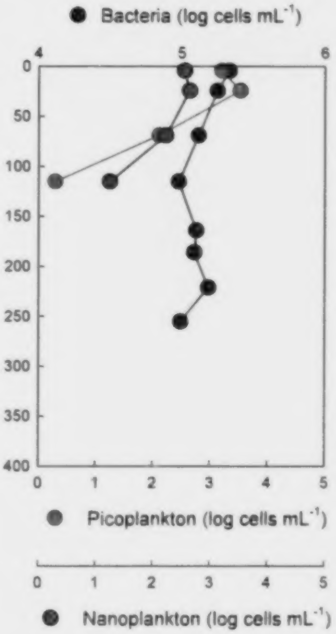
2004-16: Cast 41 CB-23



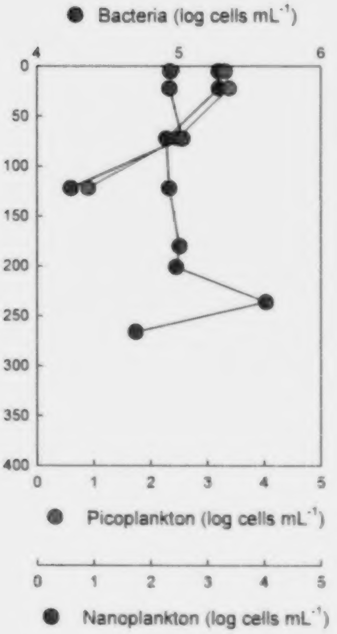
2004-16: Cast 42 CB-24



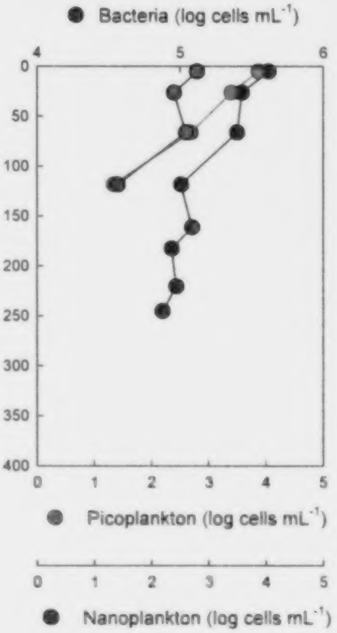
2004-16: Cast 43 CB-25



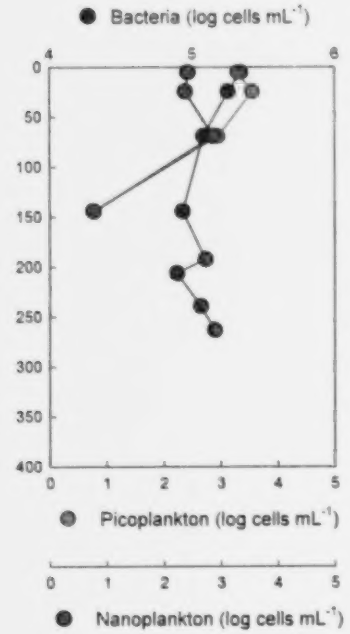
2004-16: Cast 45 CB-27



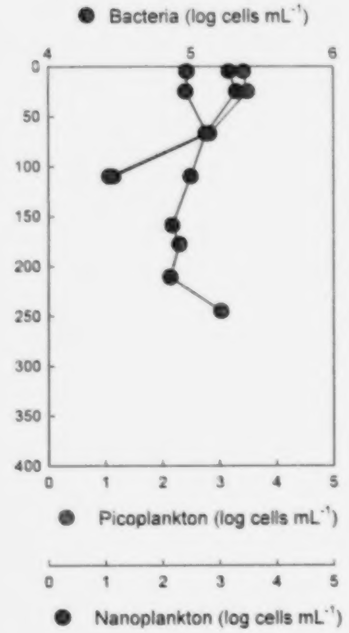
2004-16: Cast 46 CB-28



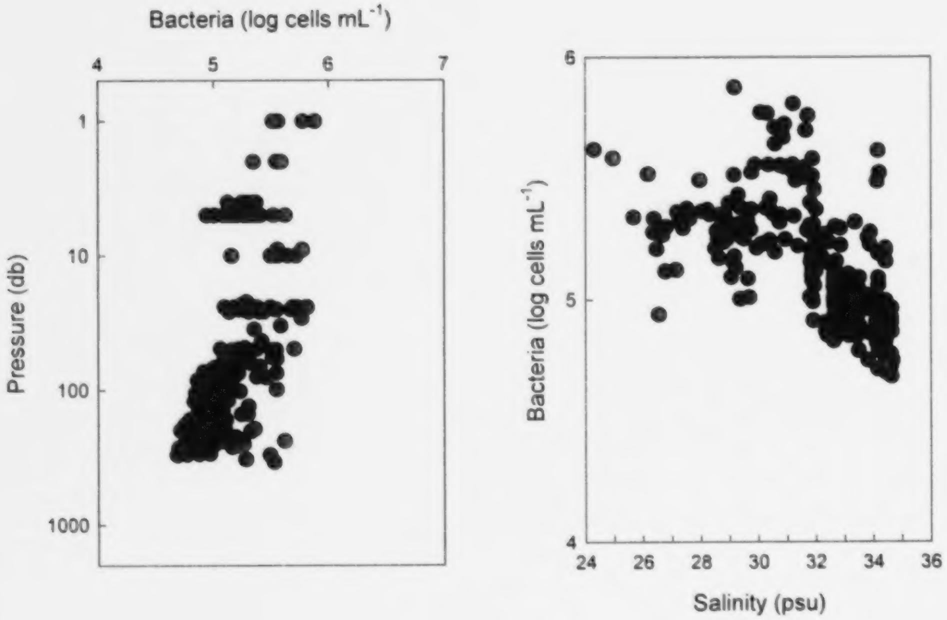
2004-16: Cast 47 CB-29



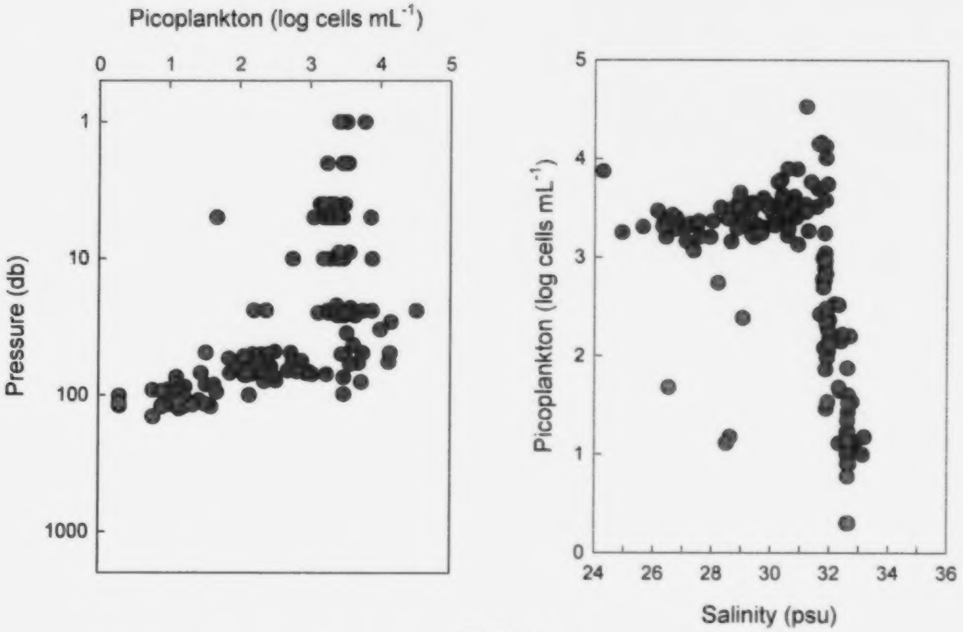
2004-16: Cast 48 CB-30



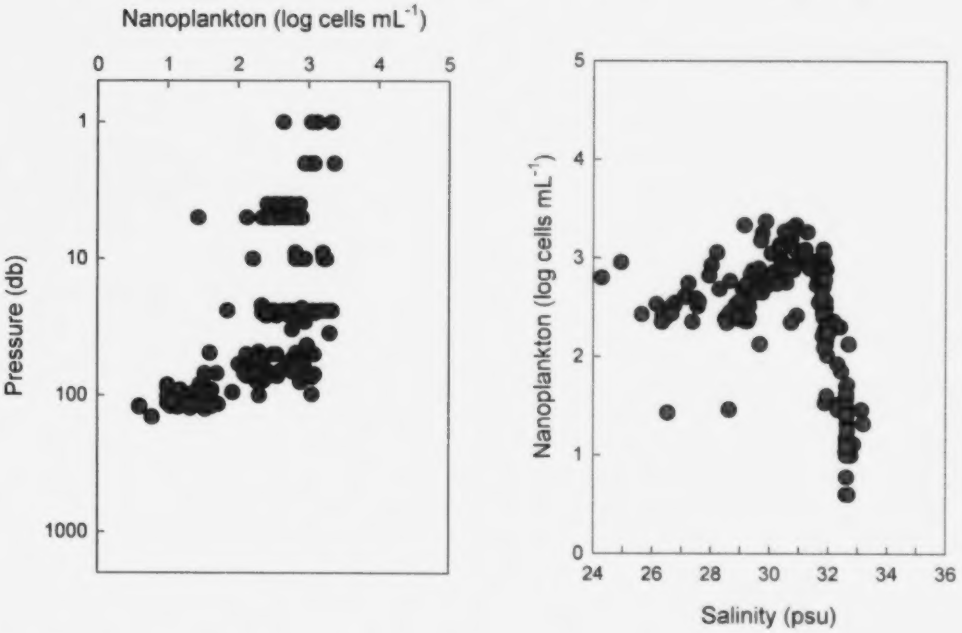
2004-16



2004-16



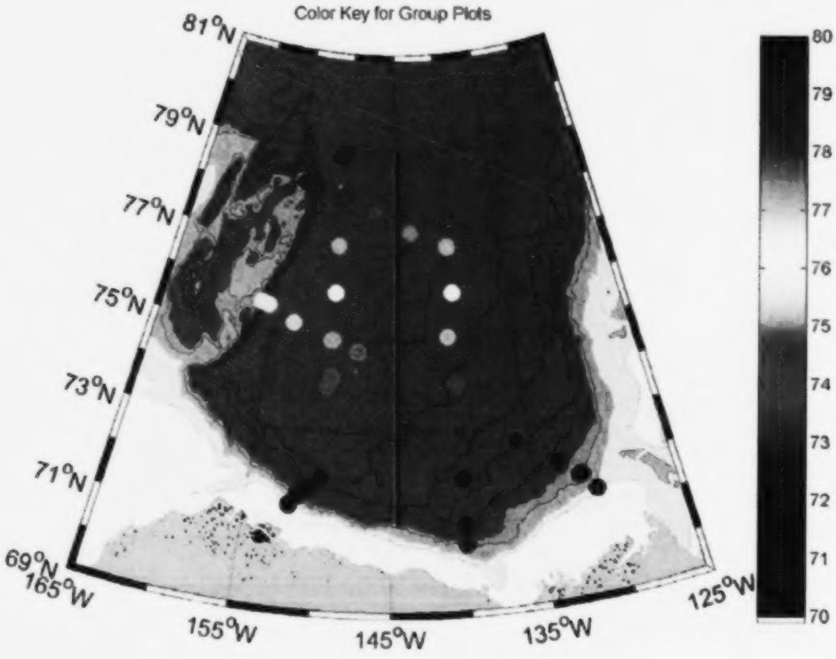
2004-16



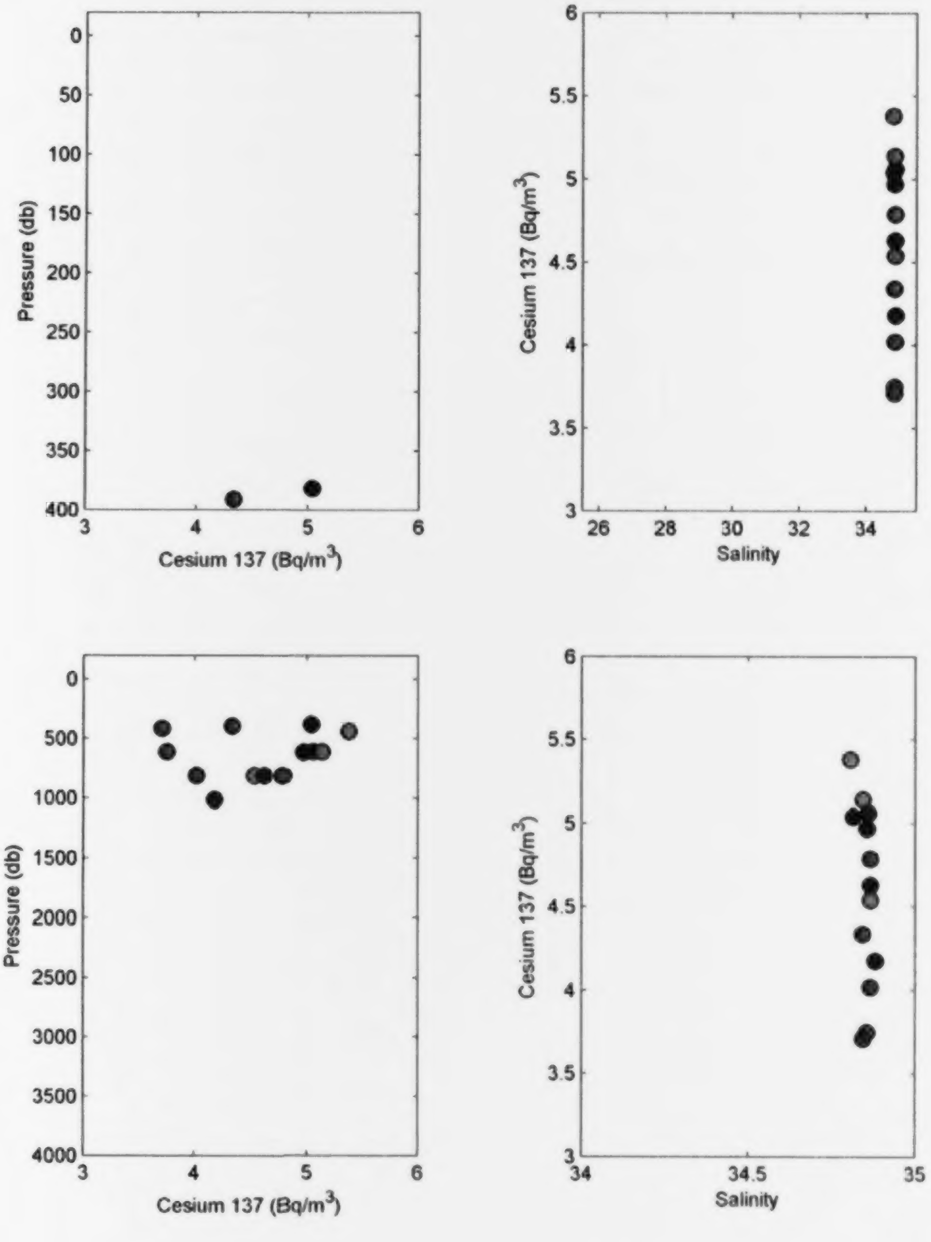
6. PROPERTY PLOTS

The Canada Basin is divided into two groups, the east side and the west side. The division line at 145°W is drawn in black. Plotted colors are the same as used in the figures below. Colors refer to latitude (°N) and are labeled in color bar.

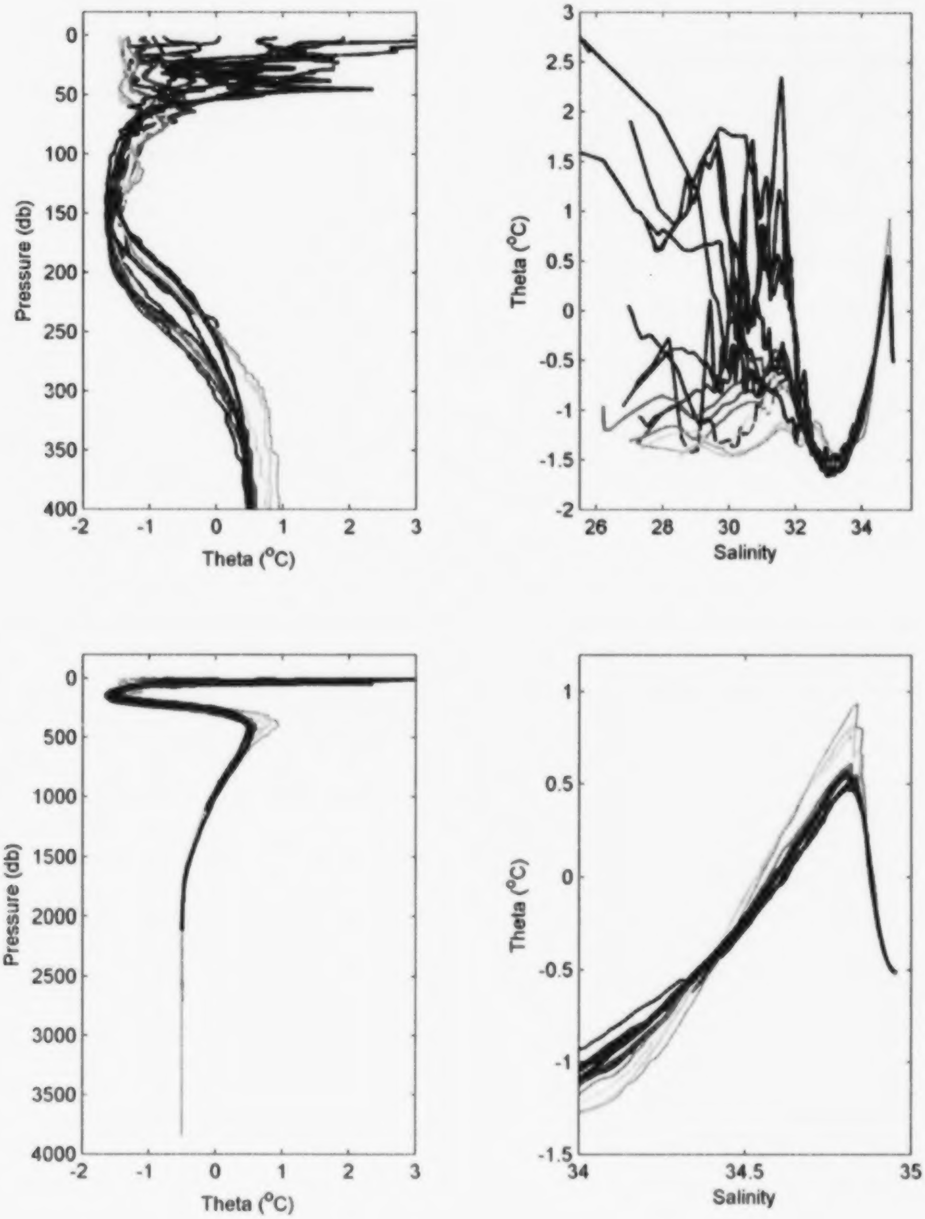
6.1 Casts in the Canada Basin


Color Key for Group Plots
81°N
79°N
77°N
75°N
73°N
71°N
69°N
165°W
155°W
145°W
135°W
125°W
80
79
78
77
76
75
74
73
72
71
70

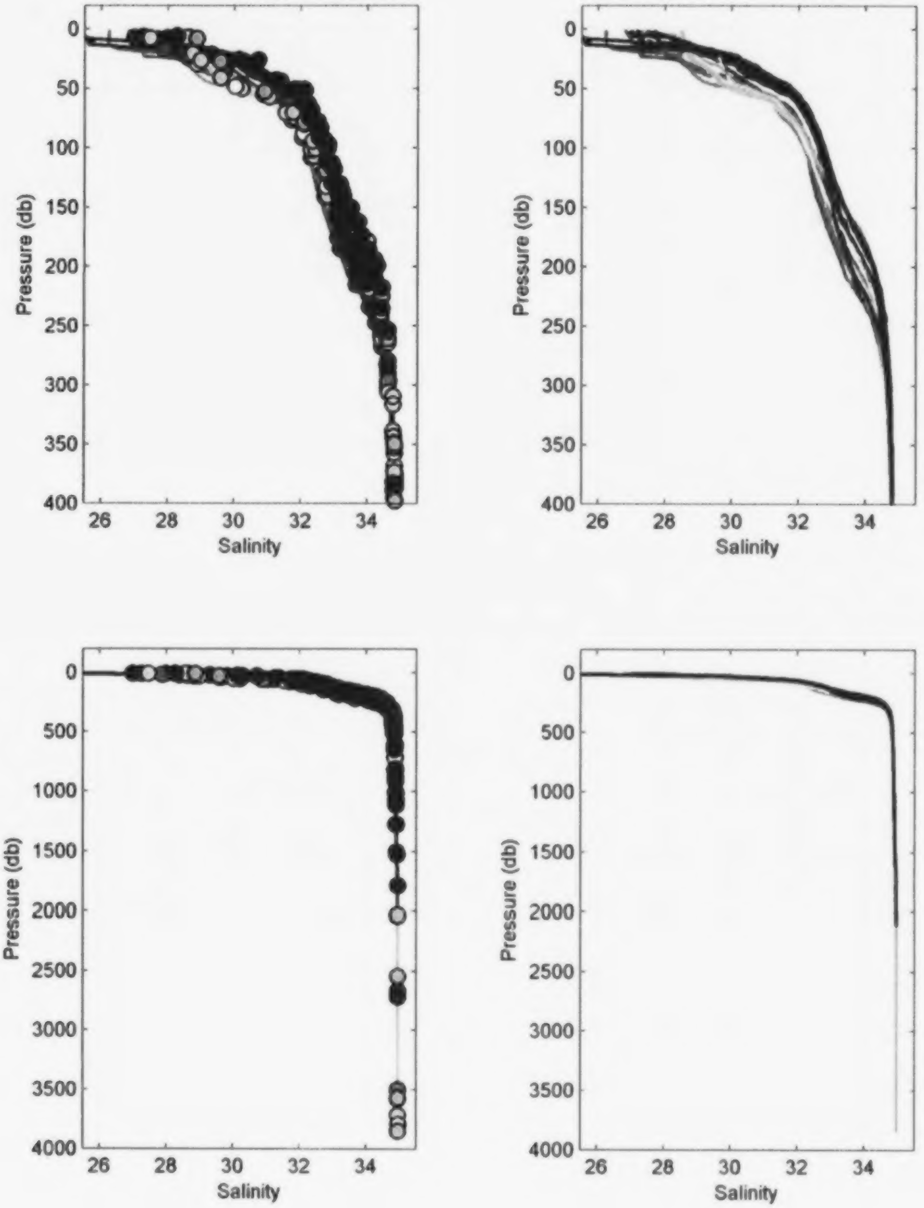
2005-04 Group: West of 145°W, Property: Cesium-137



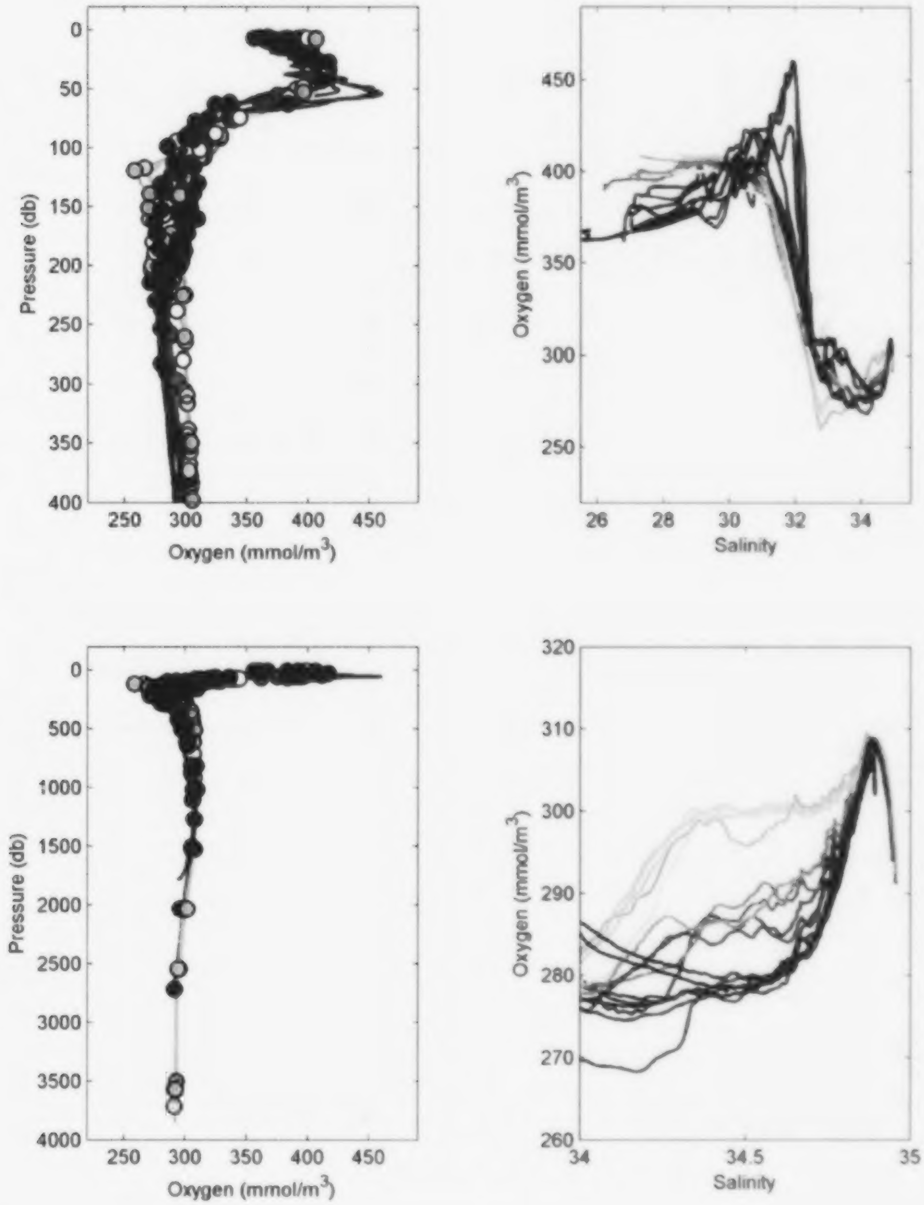
2005-04 Group: East of 145°W, Property: Theta



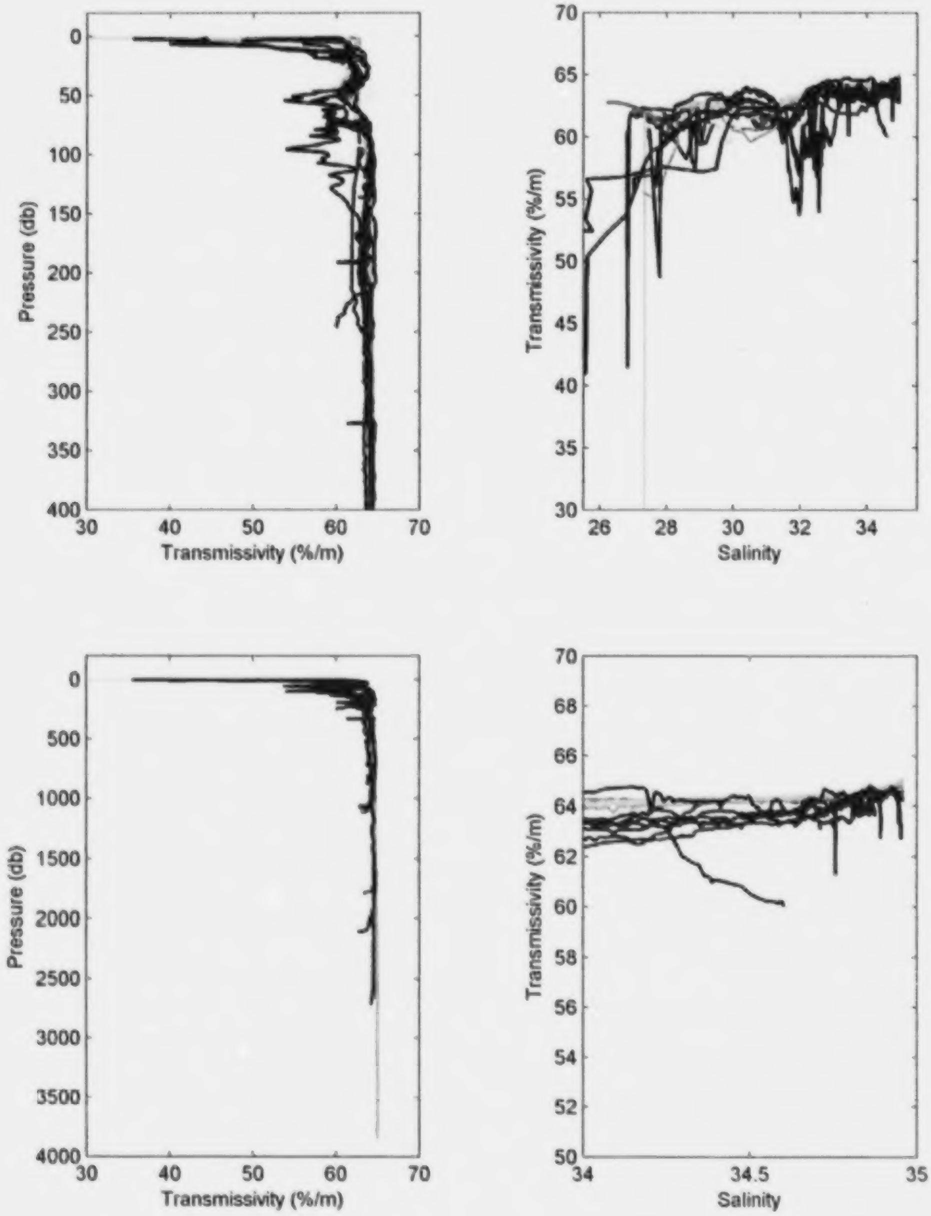
2005-04 Group: East of 145°W, Property: Salinity



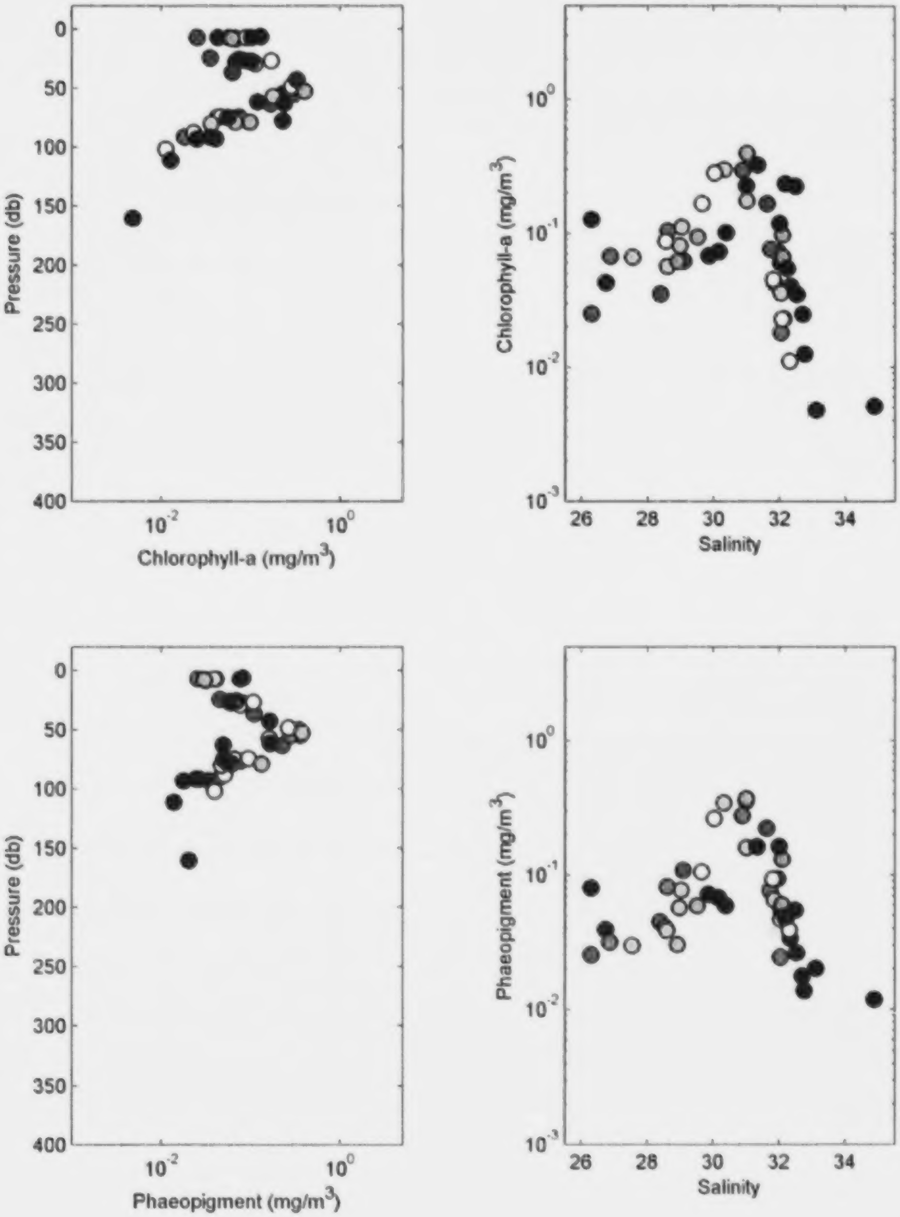
2005-04 Group: East of 145°W, Property: Oxygen



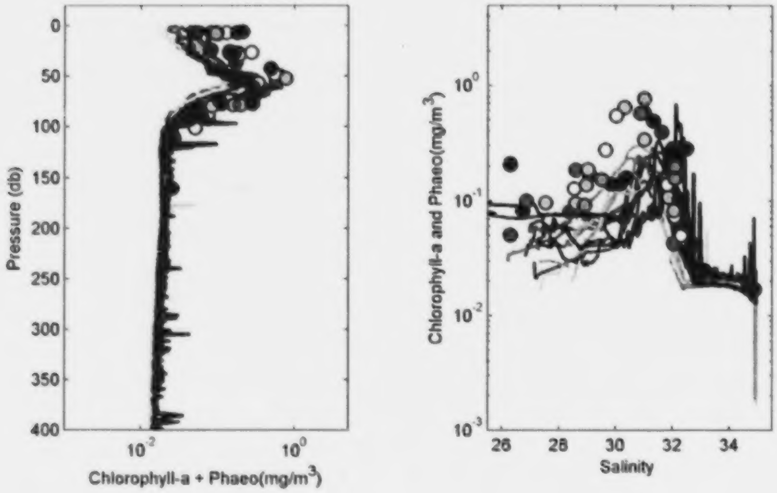
2005-04 Group: East of 145°W, Property: Transmission



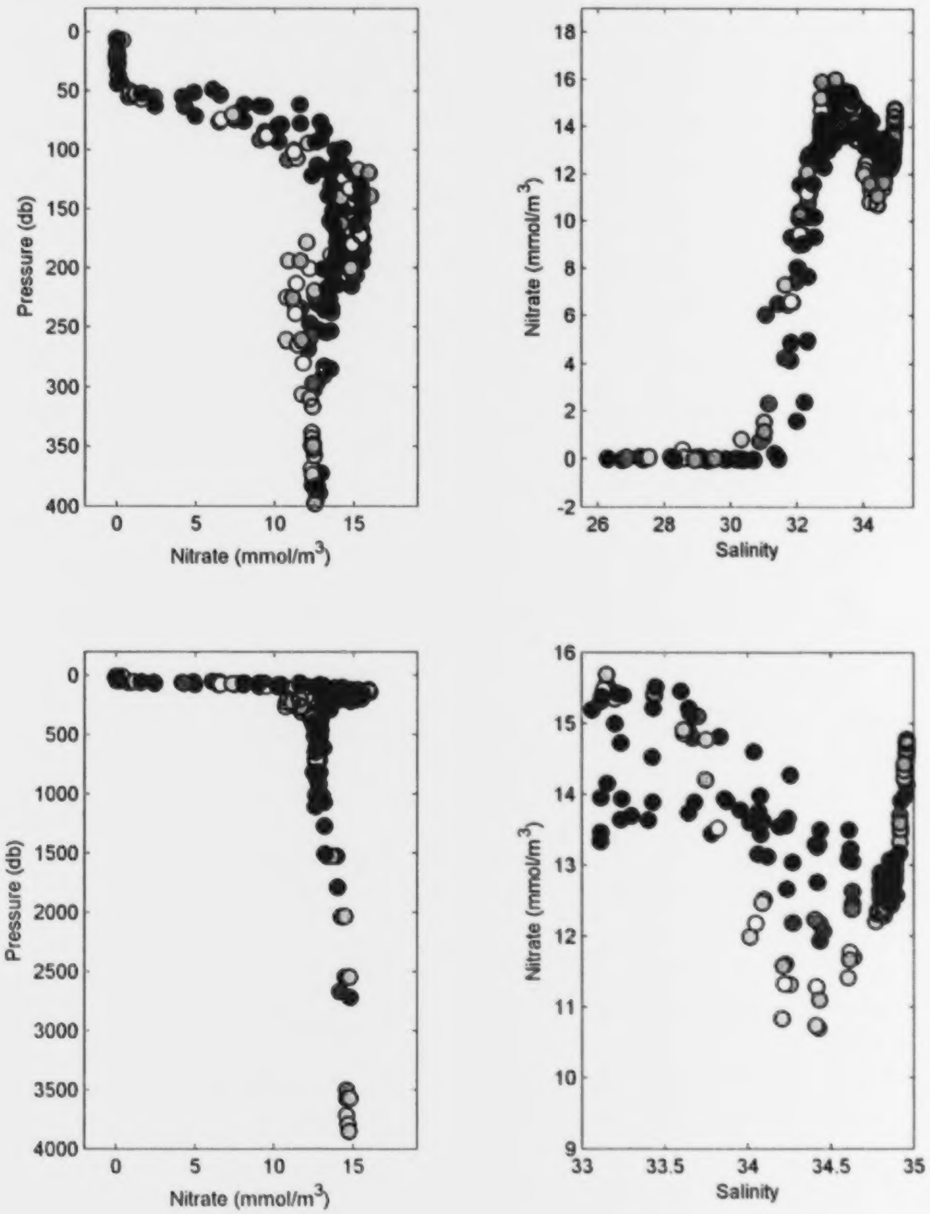
2005-04 Group: East of 145°W, Property: Chlorophyll-a, Phaeopigment



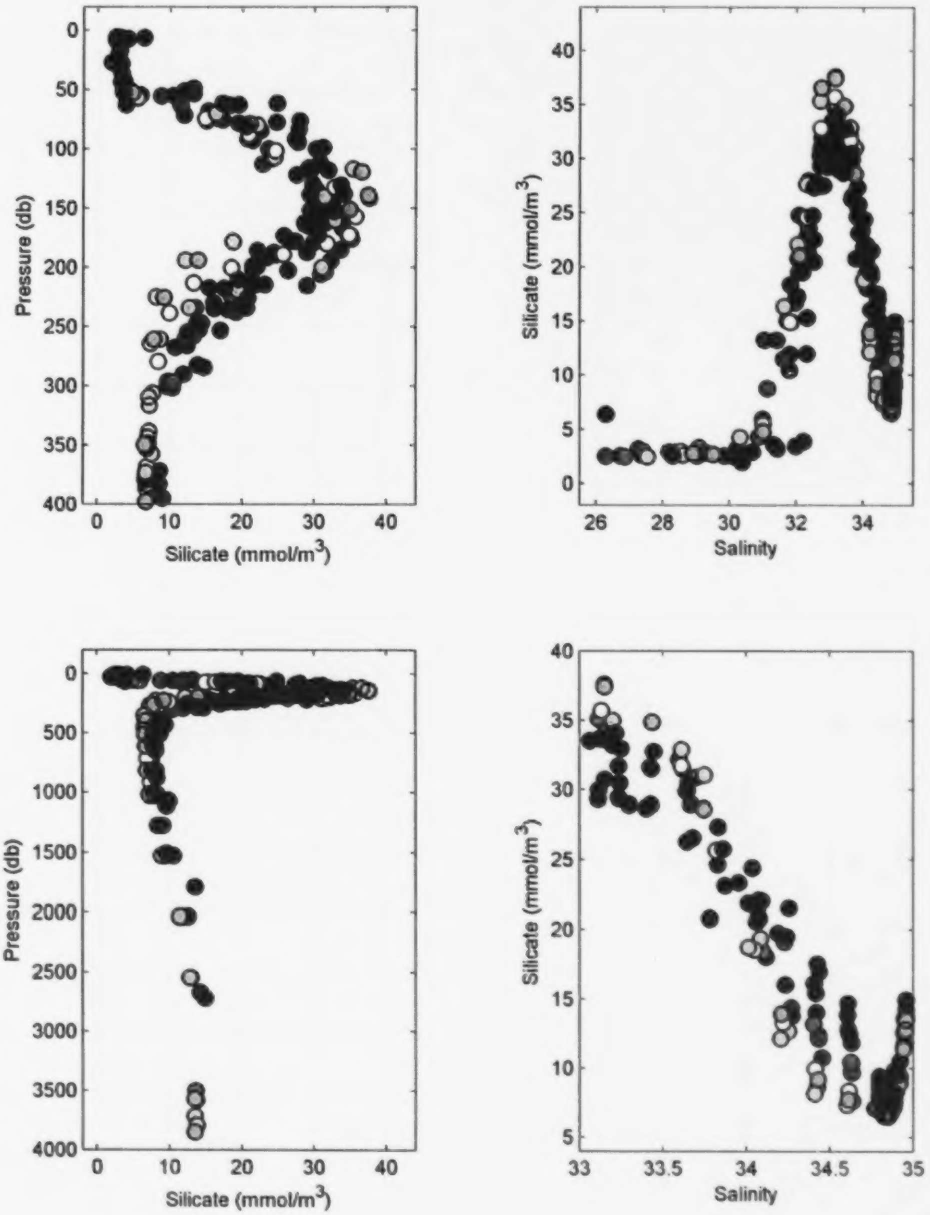
2005-04 Group: East of 145°W, Property: Combined Chlorophyll-a and Phaeopigment



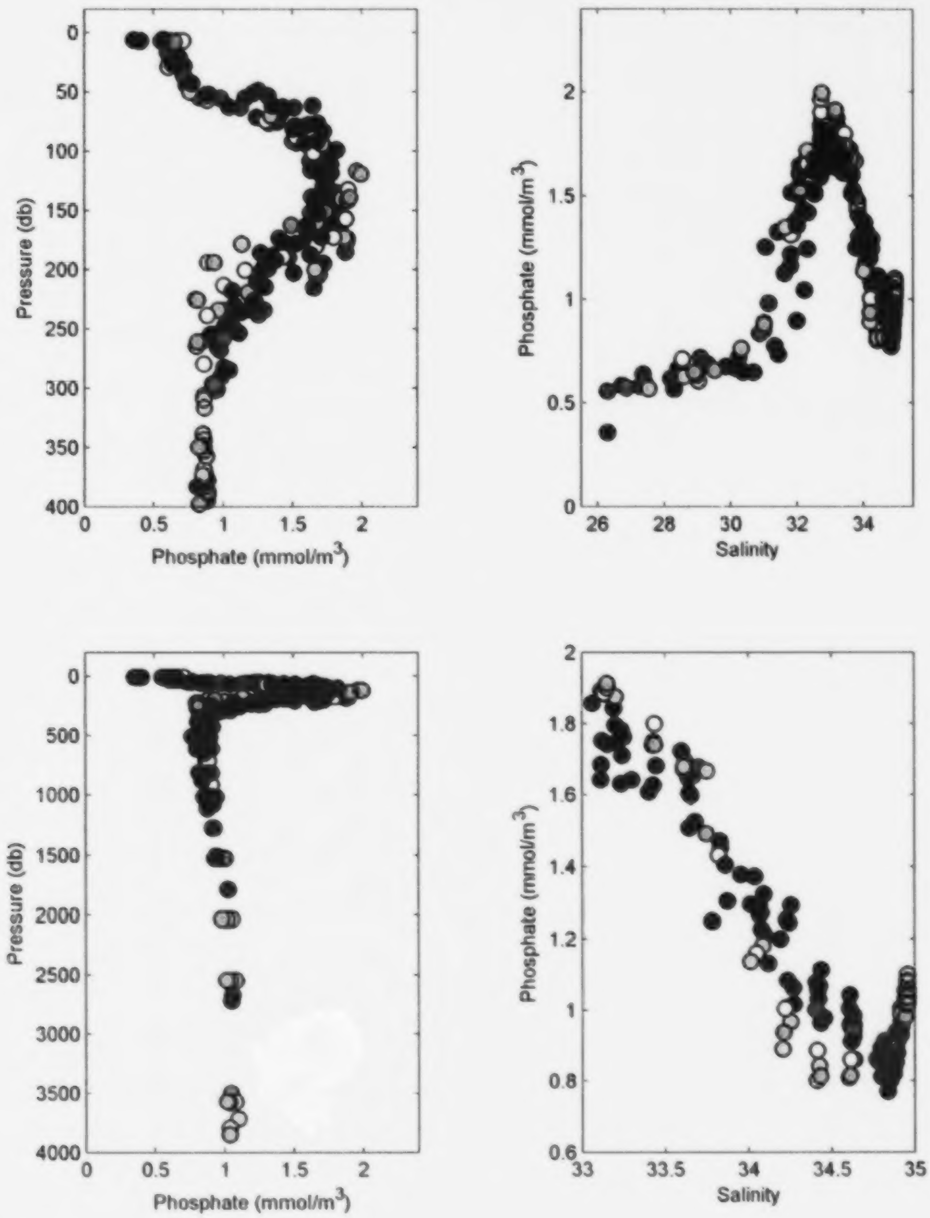
2005-04 Group: East of 145°W, Property: Nitrate and Nitrite



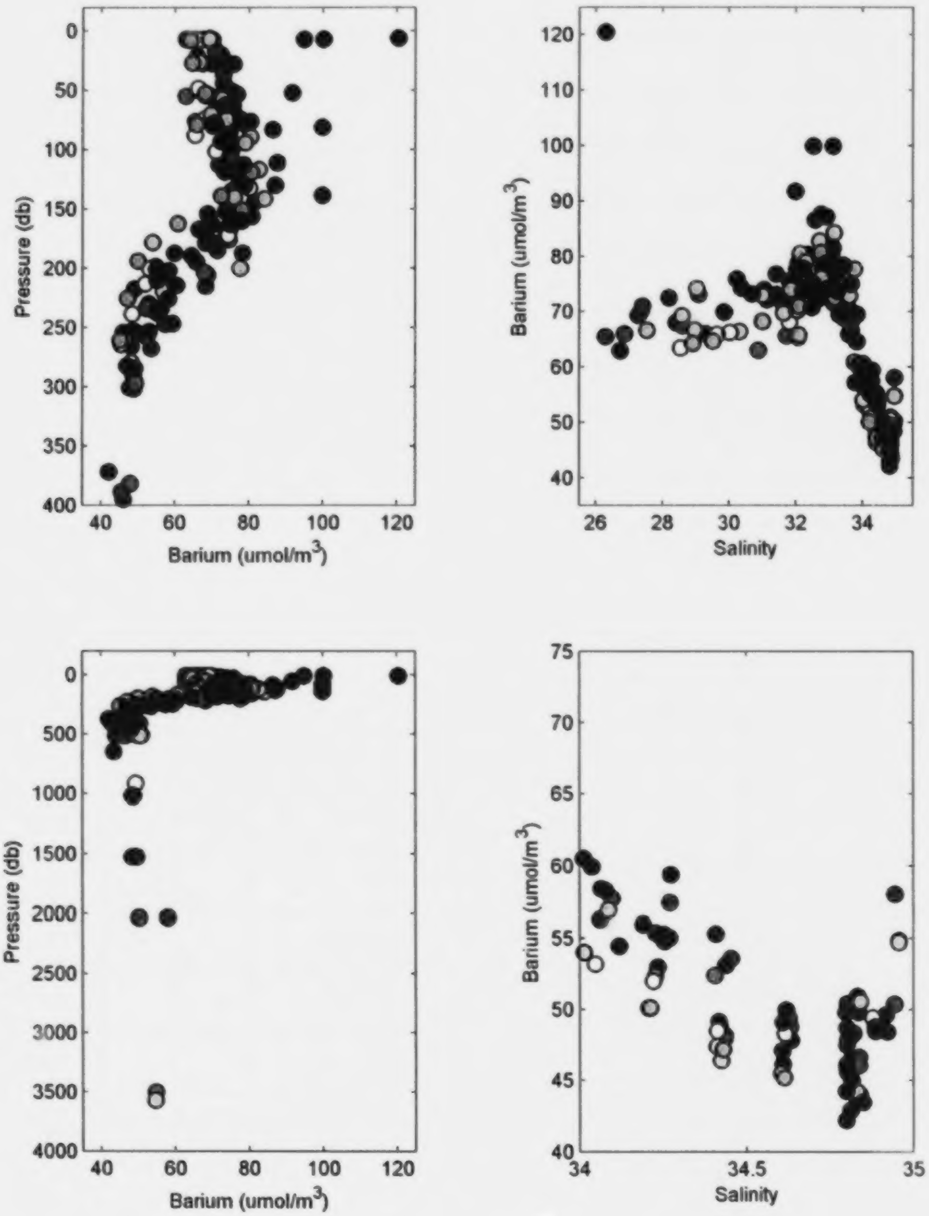
2005-04 Group: East of 145°W, Property: Silicate



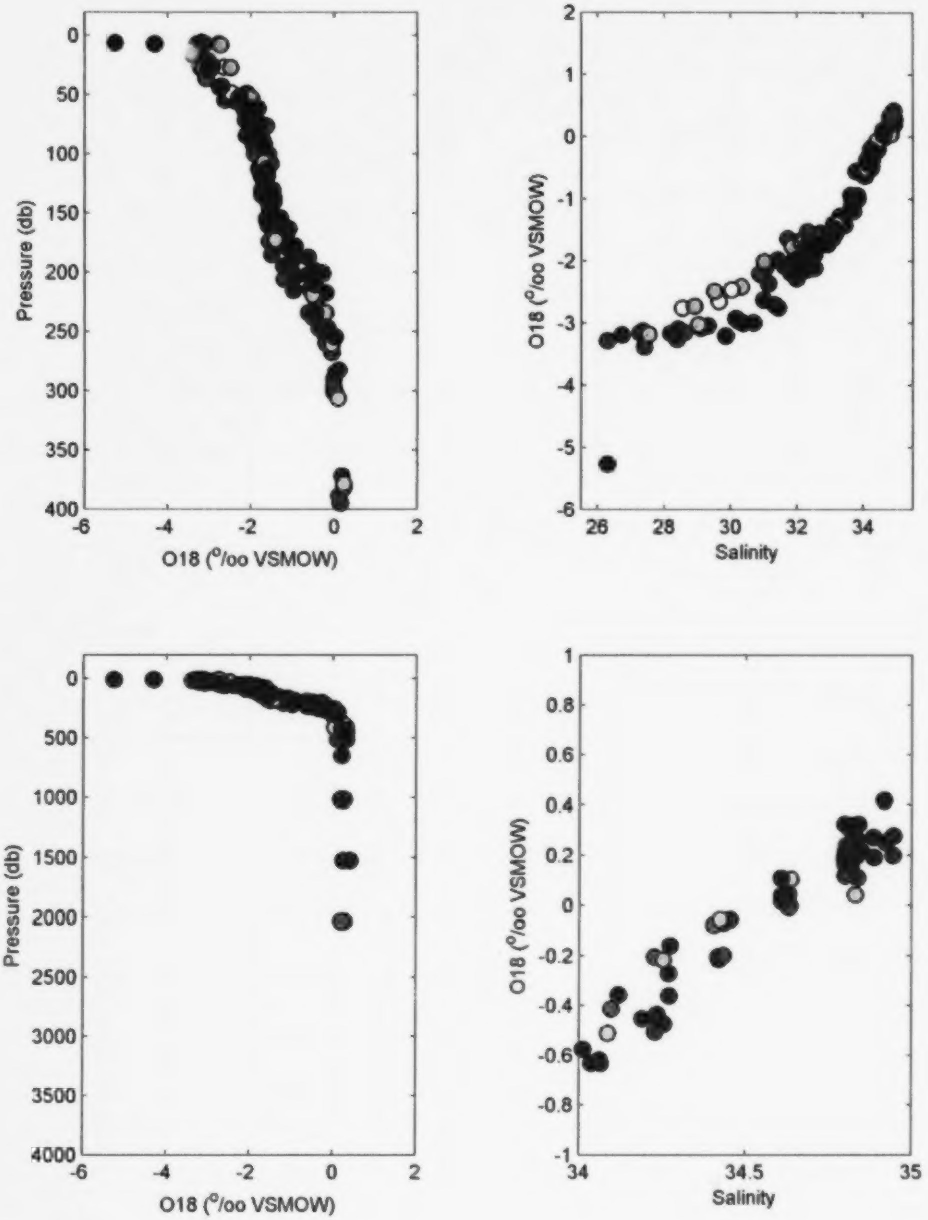
2005-04 Group: East of 145°W, Property: Phosphate



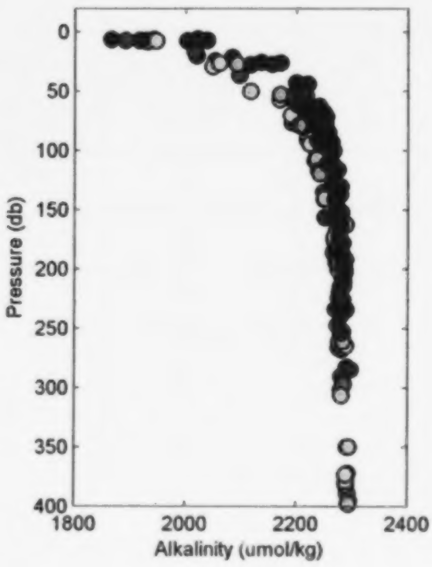
2005-04 Group: East of 145°W, Property: Barium

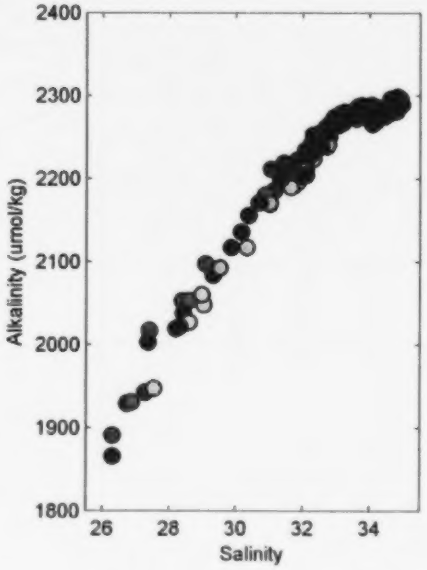


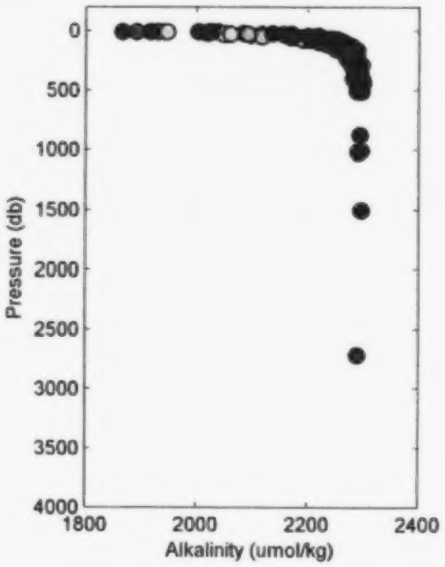
2005-04 Group: East of 145°W, Property: O18

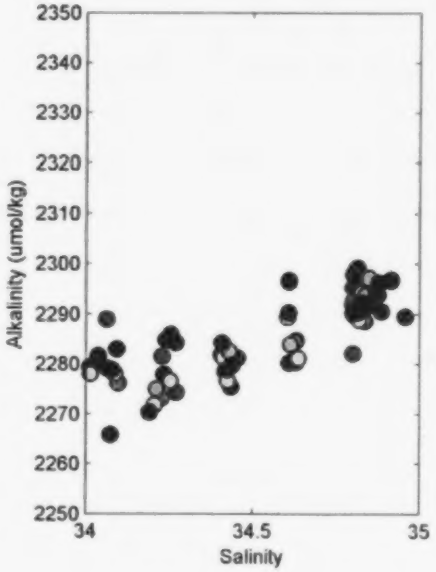


2005-04 Group: East of 145°W, Property: Alkalinity

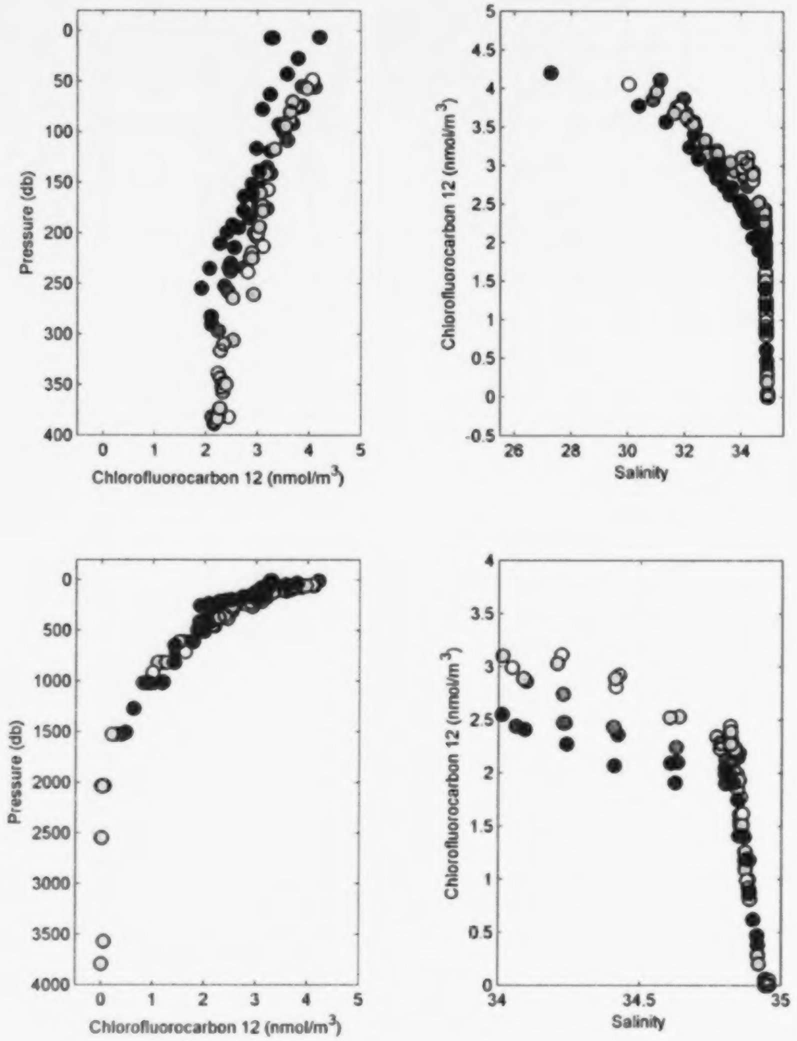




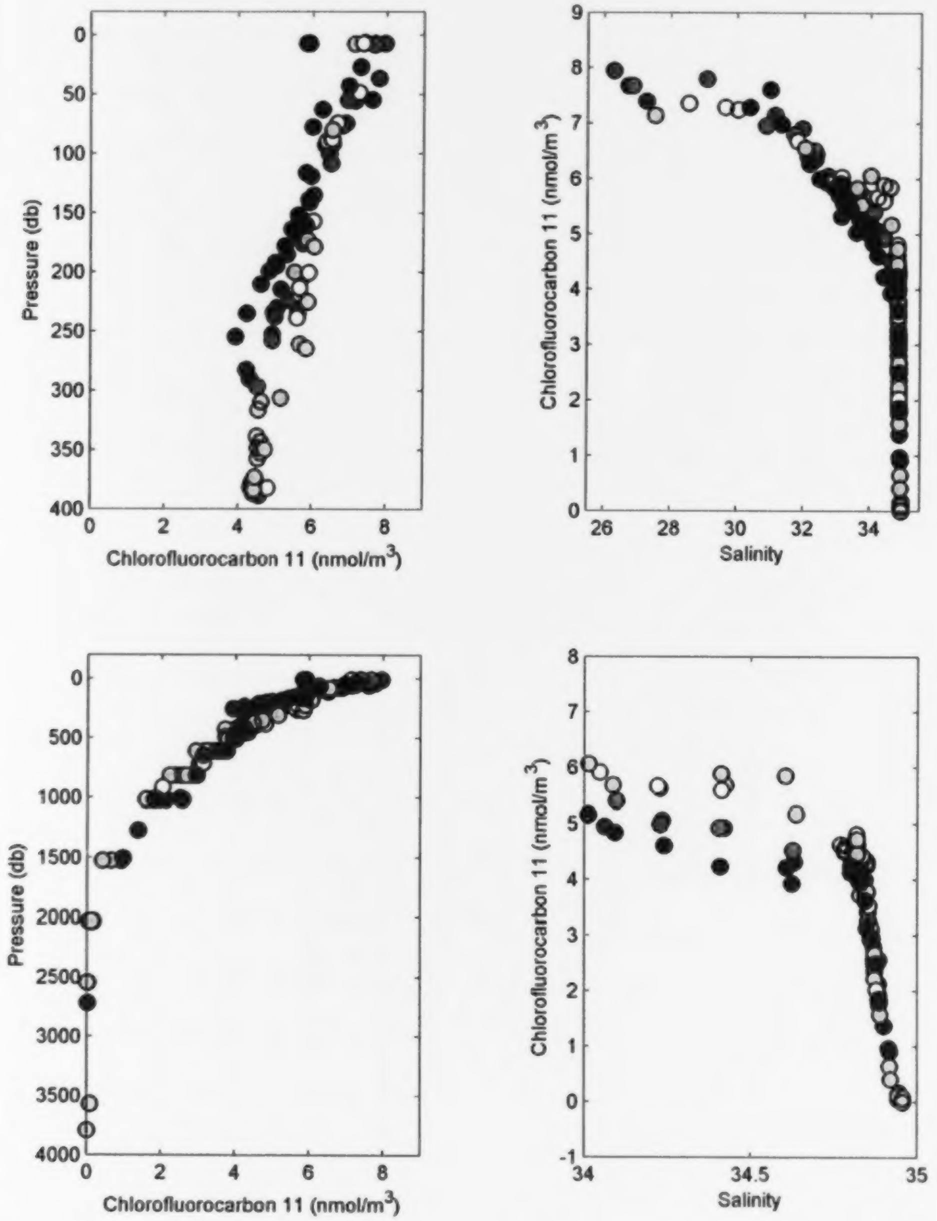




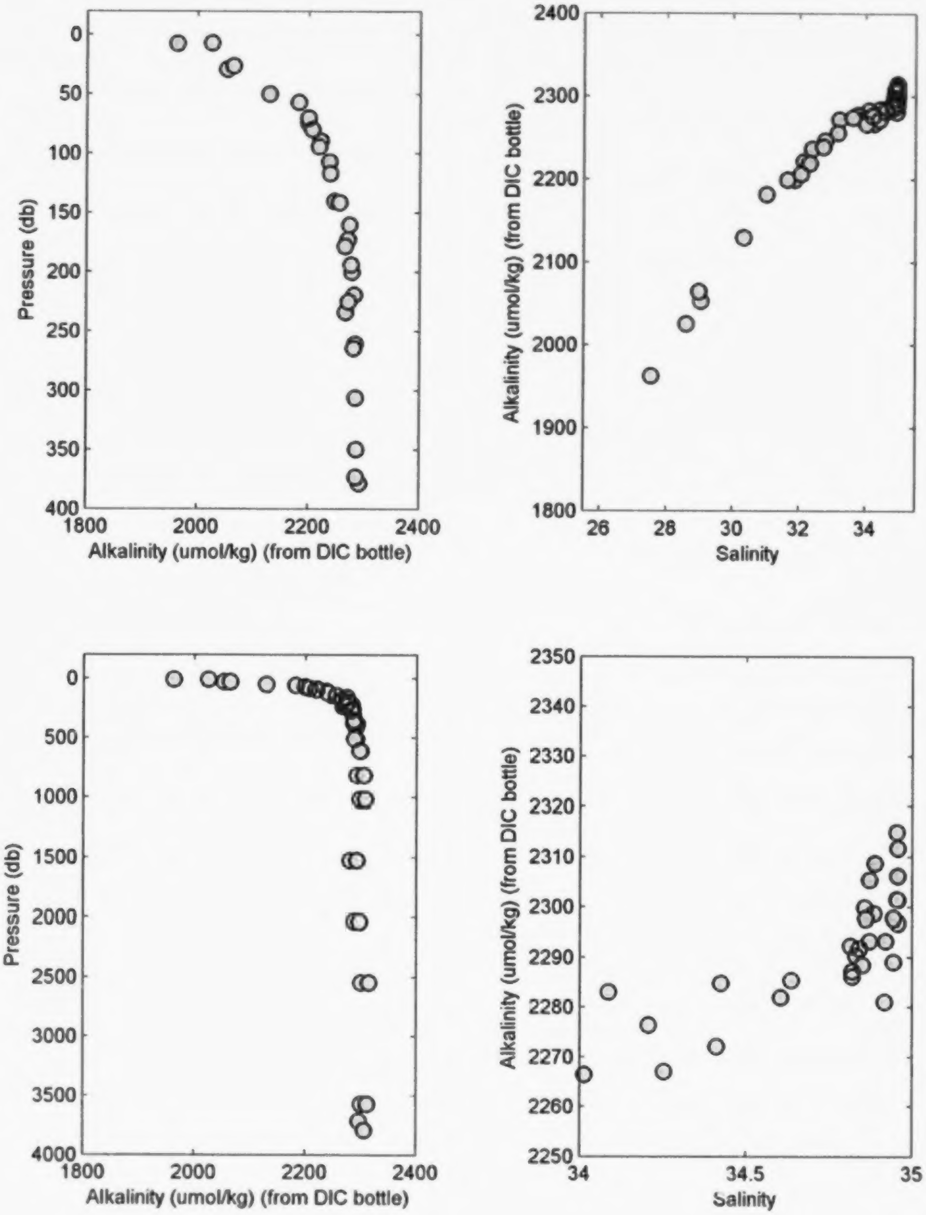
2005-04 Group: East of 145°W, Property: Chlorofluorcarbon-12



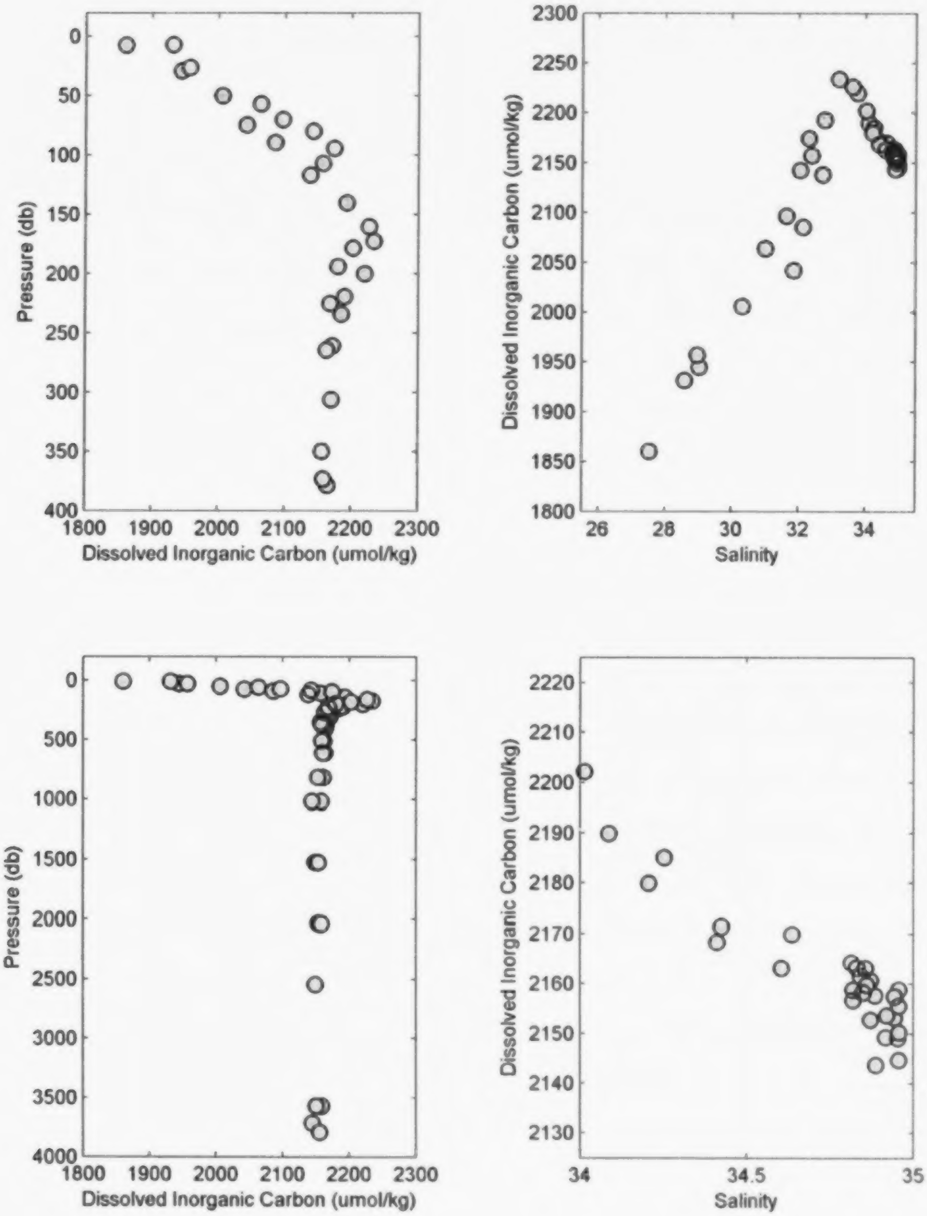
2005-04 Group: East of 145°W, Property: Chlorofluorcarbon-11



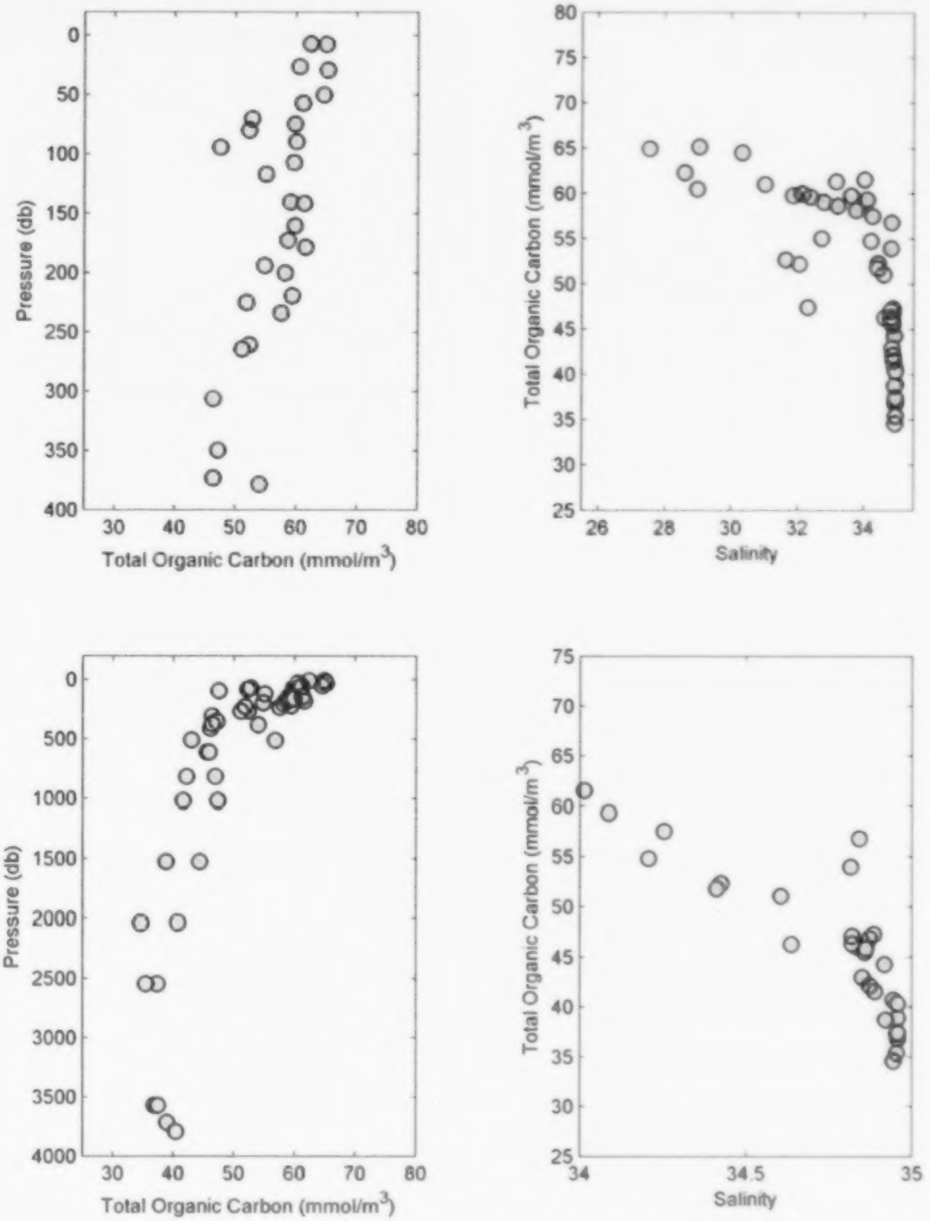
2005-04 Group: East of 145°W, Property: Alkalinity (from DIC bottle)



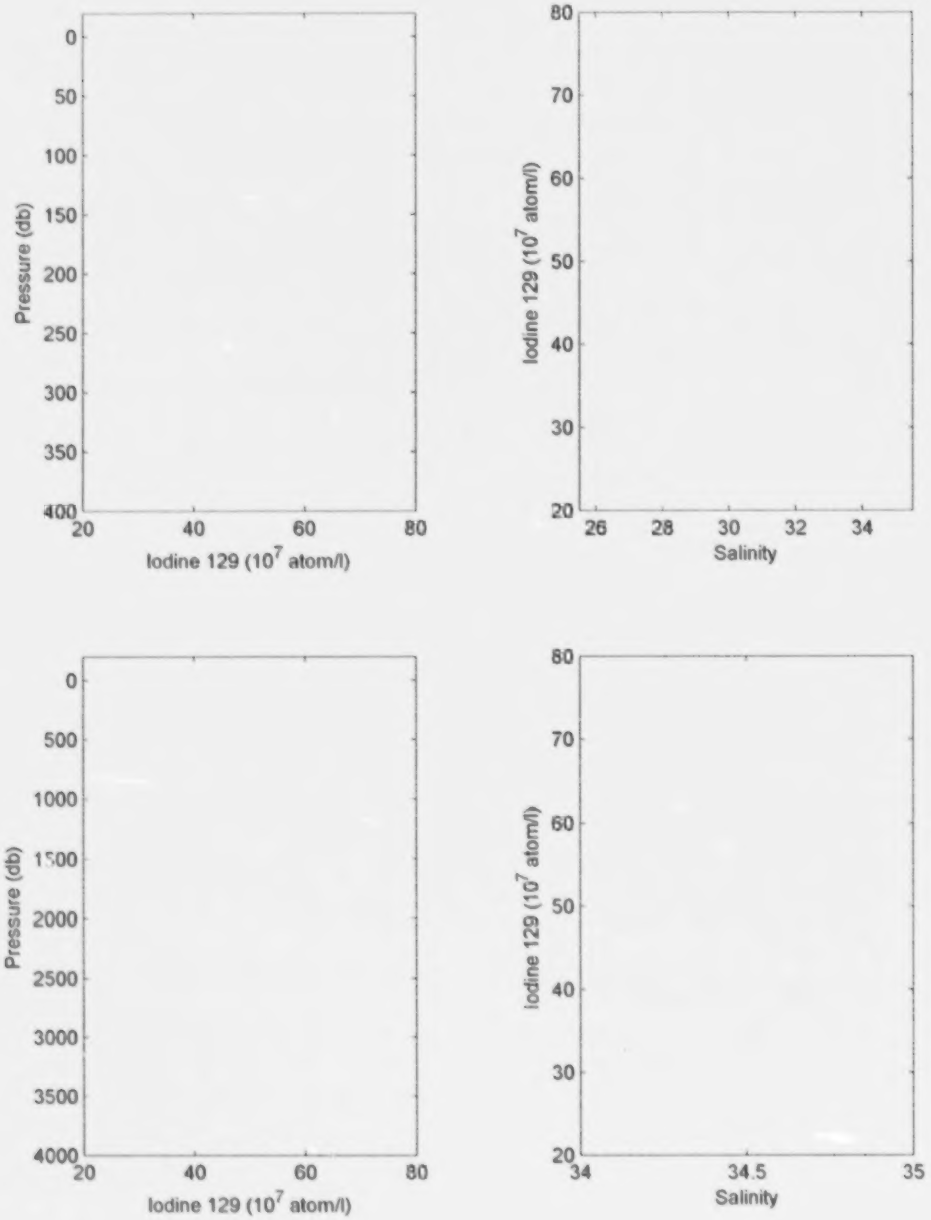
2005-04 Group: East of 145°W, Property: Dissolved Inorganic Carbon



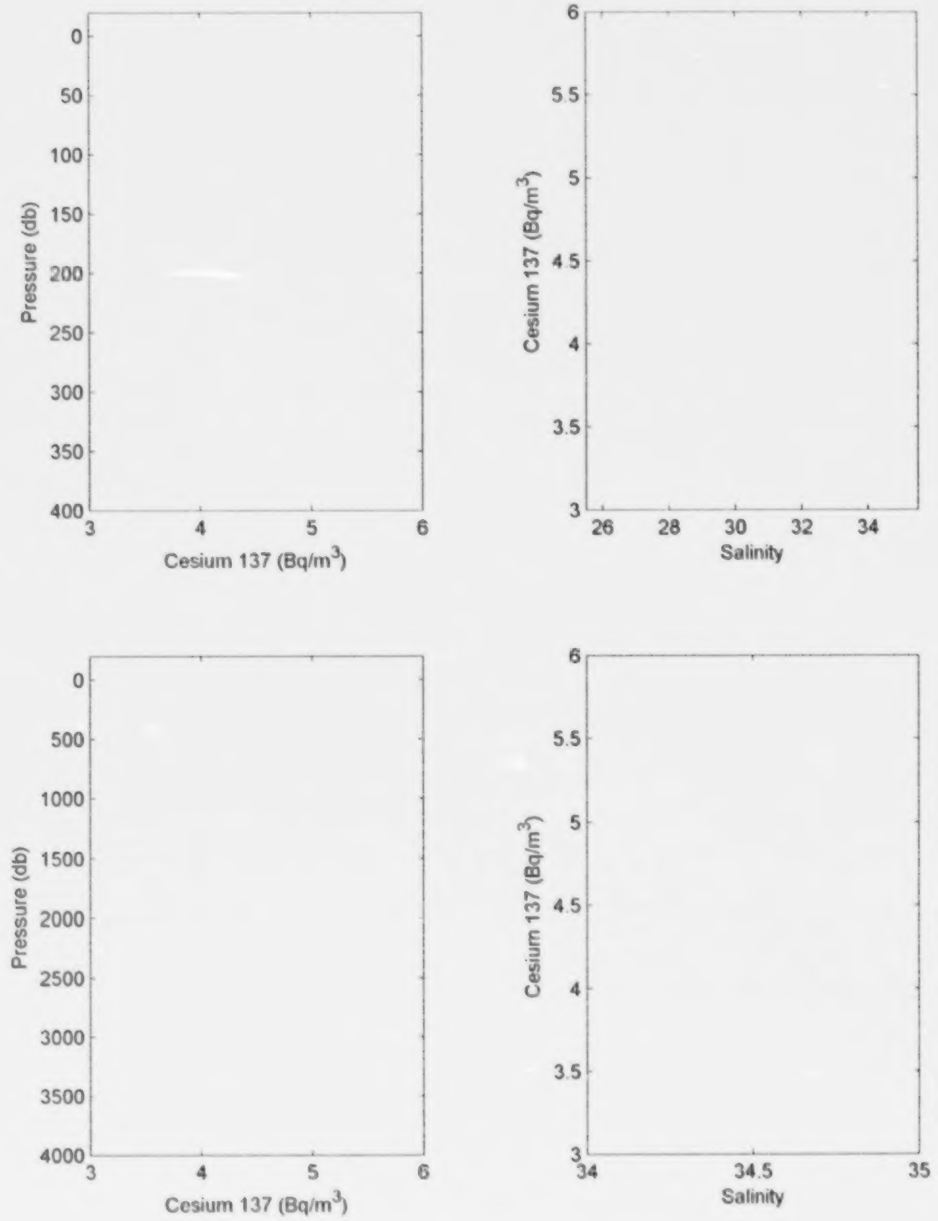
2005-04 Group: East of 145°W. Property: Total Organic Carbon



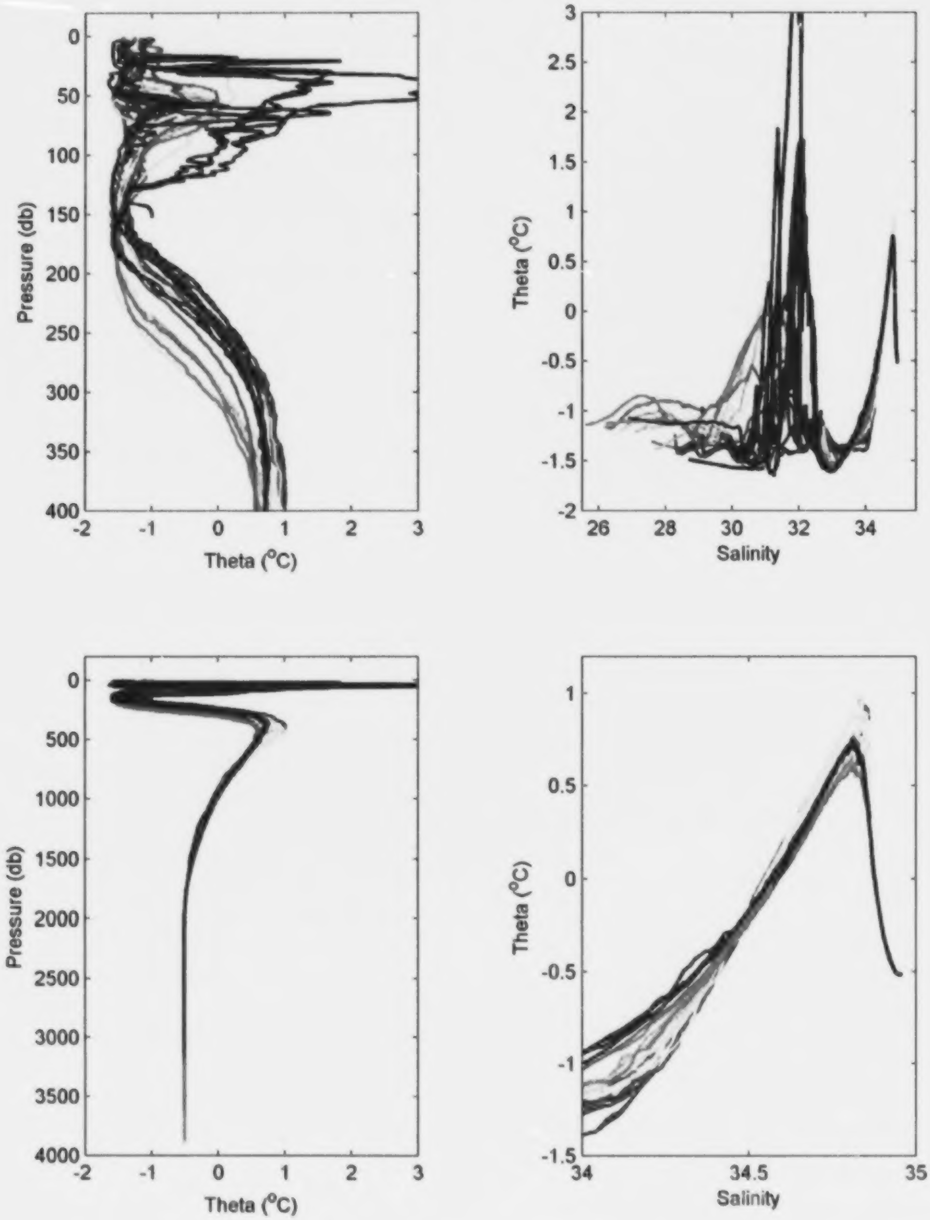
2005-04 Group: East of 145°W, Property: Iodine-129



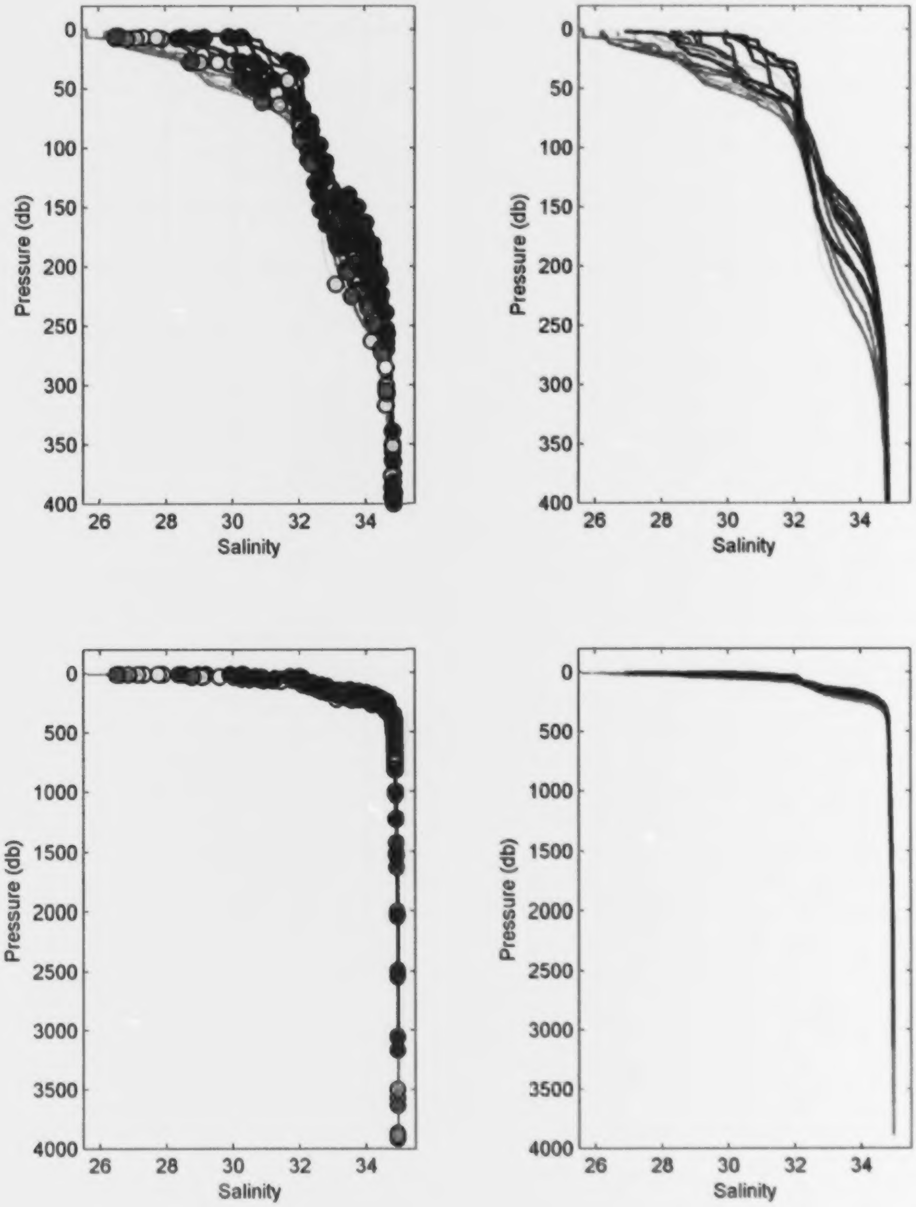
2005-04 Group: East of 145°W, Property: Cesium-137



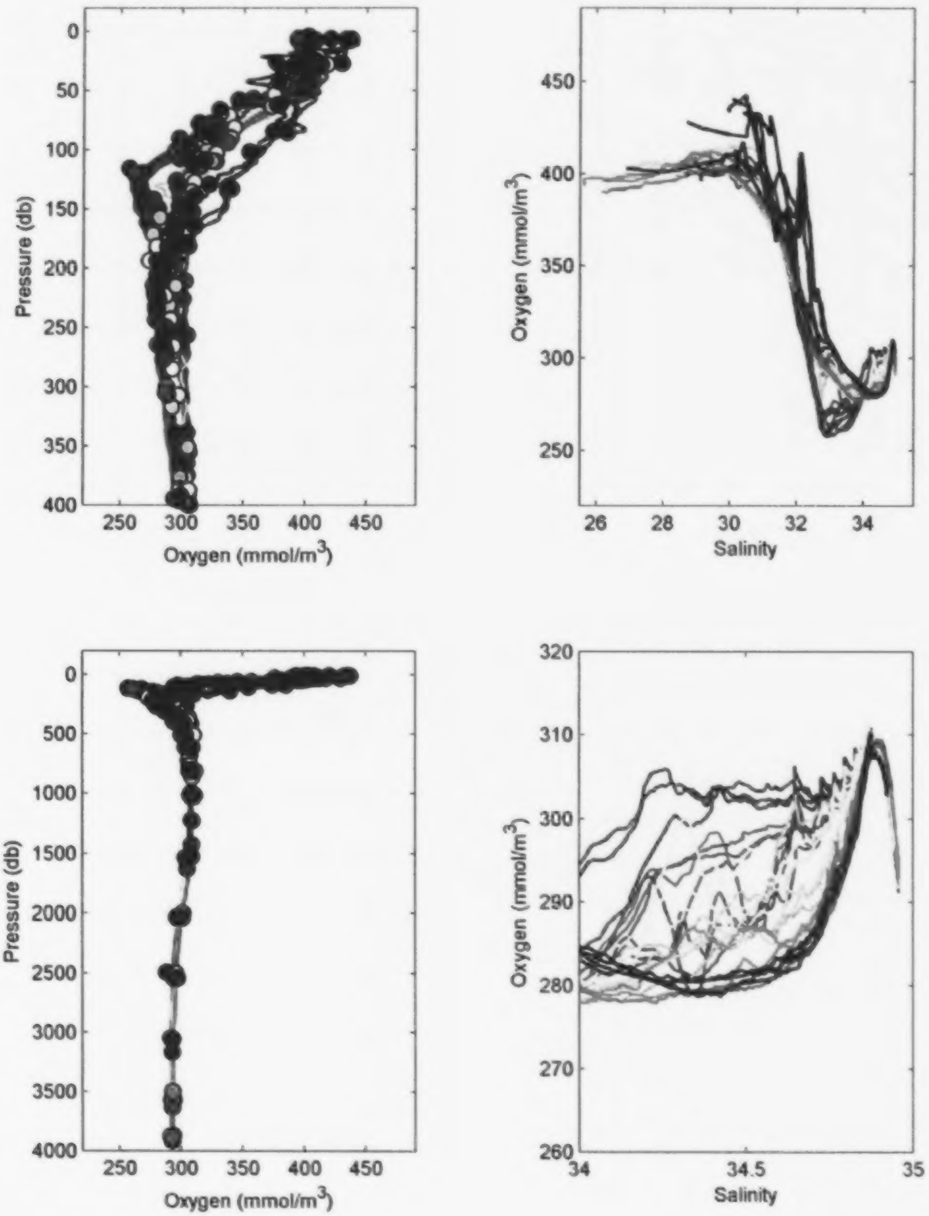
2005-04 Group: West of 145°W, Property: Theta



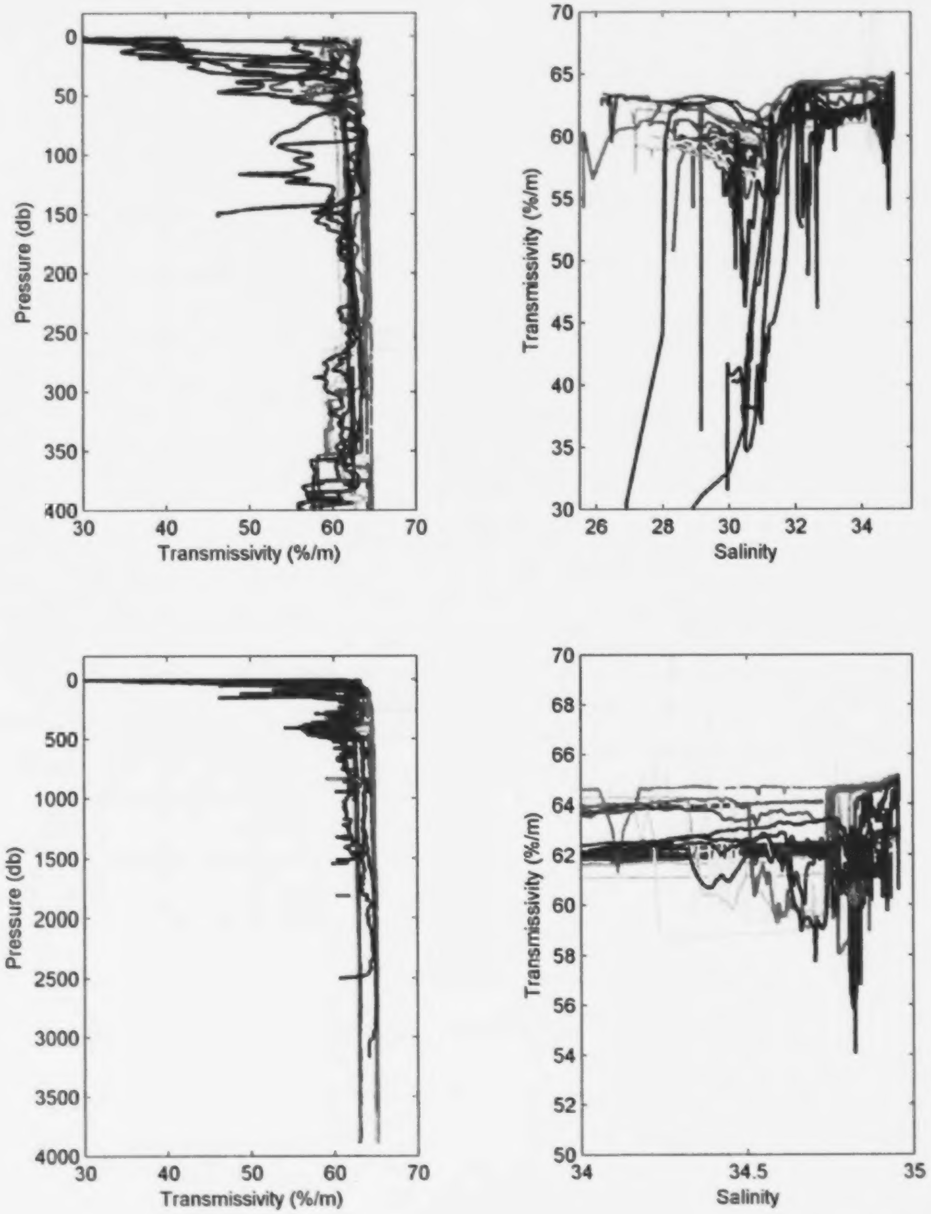
2005-04 Group: West of 145°W, Property: Salinity



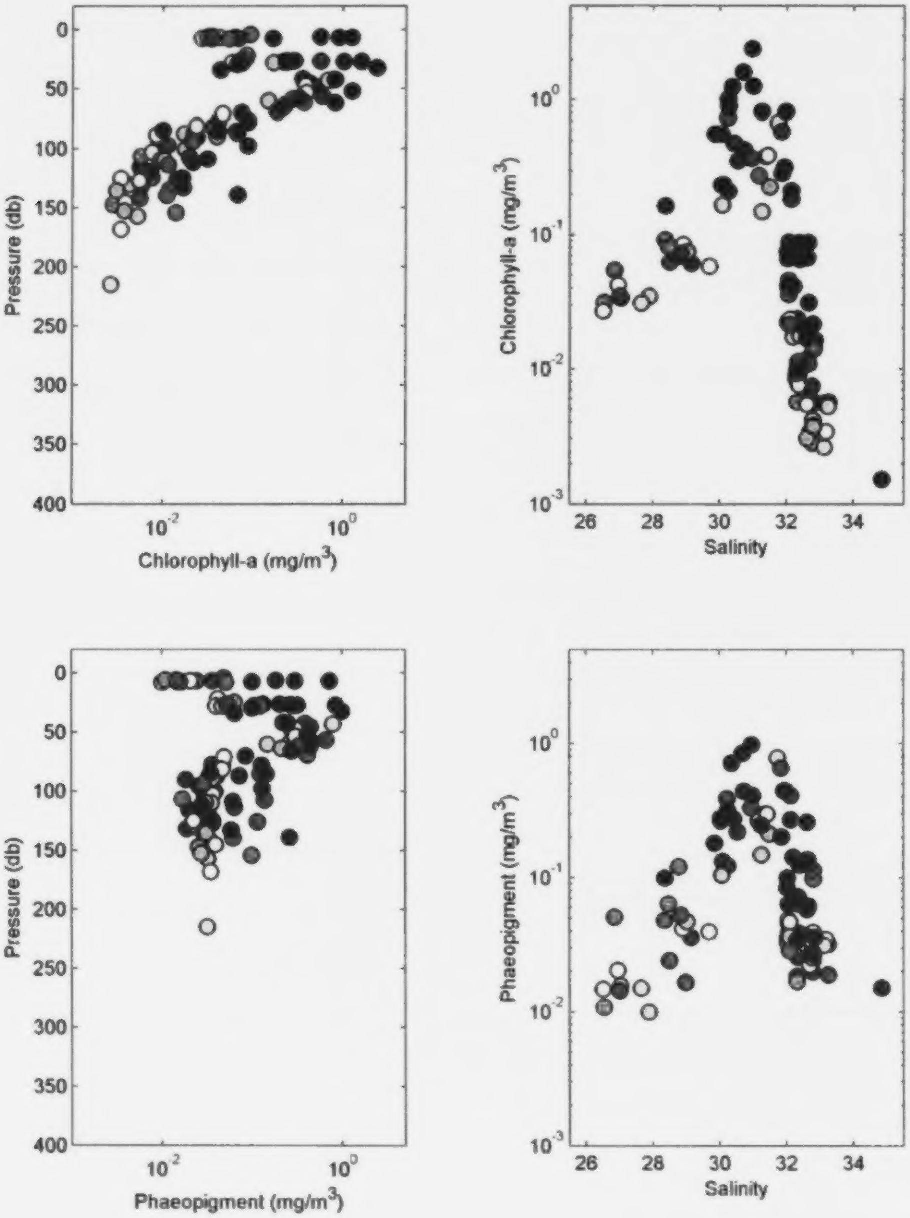
2005-04 Group: West of 145°W, Property: Oxygen



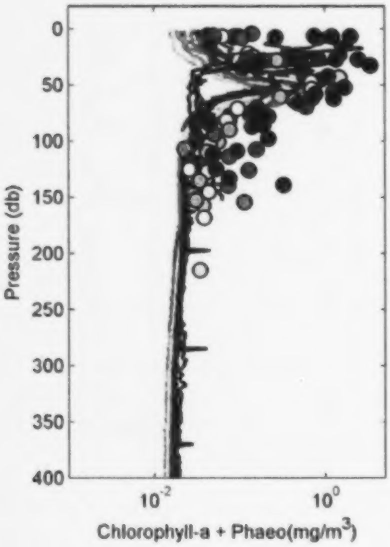
2005-04 Group: West of 145°W, Property: Transmission

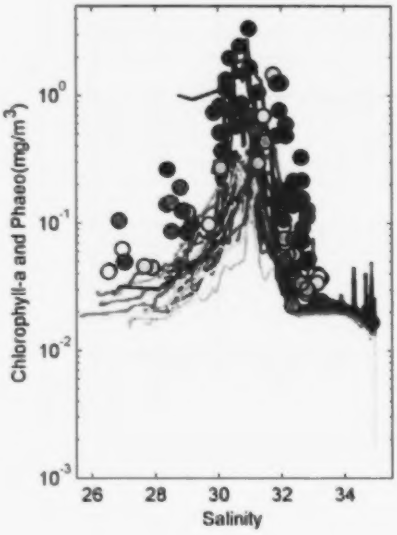


2005-04 Group: West of 145°W, Property: Chlorophyll-a, Phaeopigment

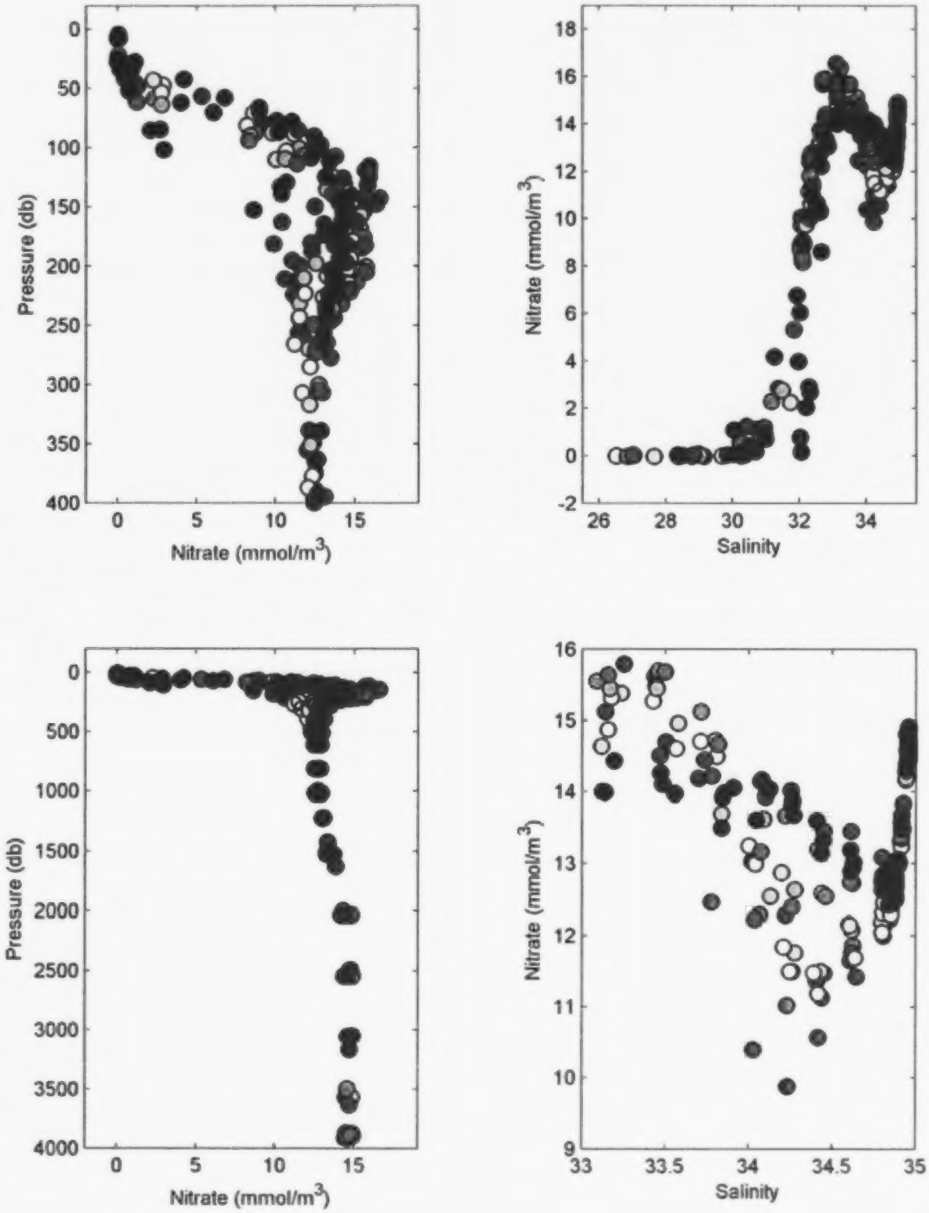


2005-04 Group: West of 145°W, Property: Combined Chlorophyll-a and Phaeopigment

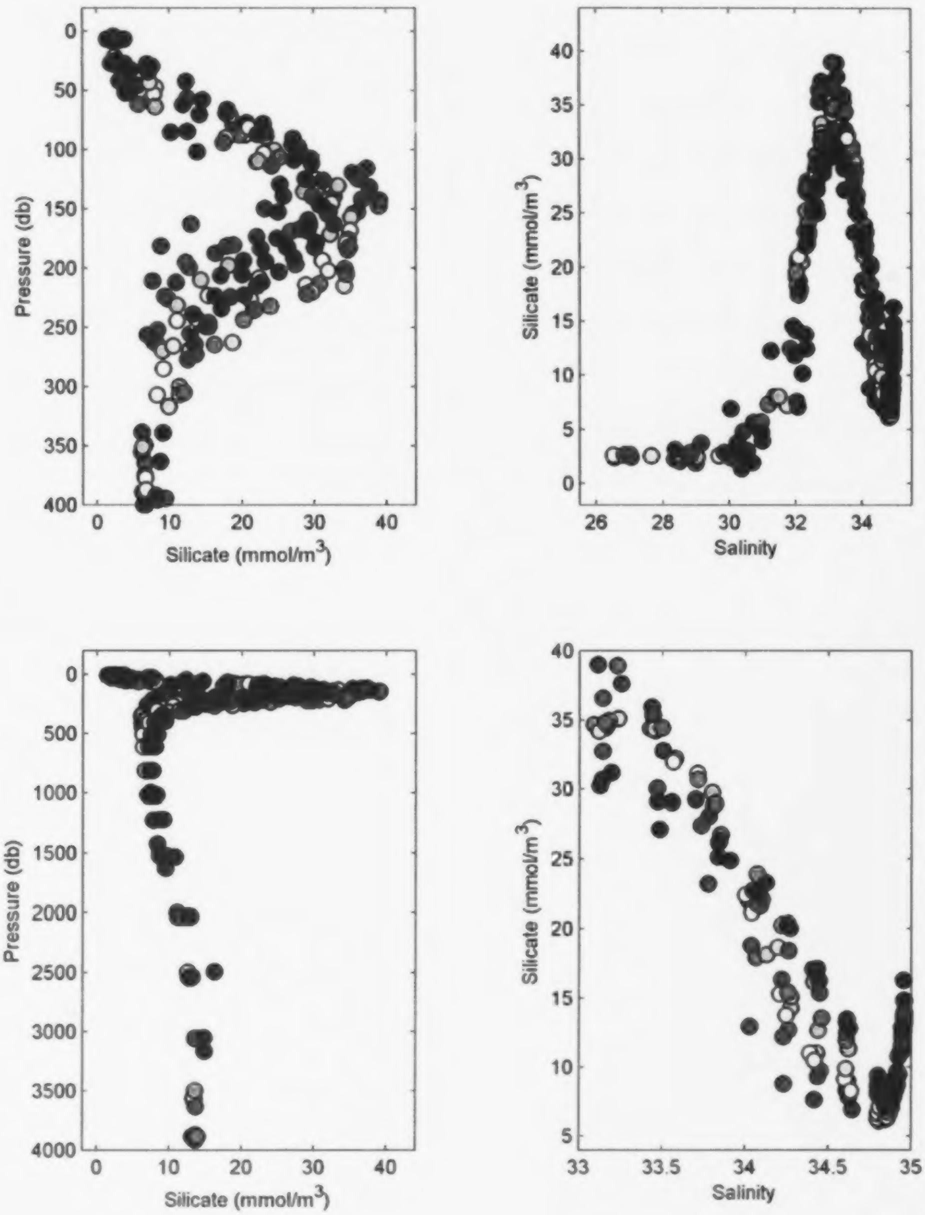




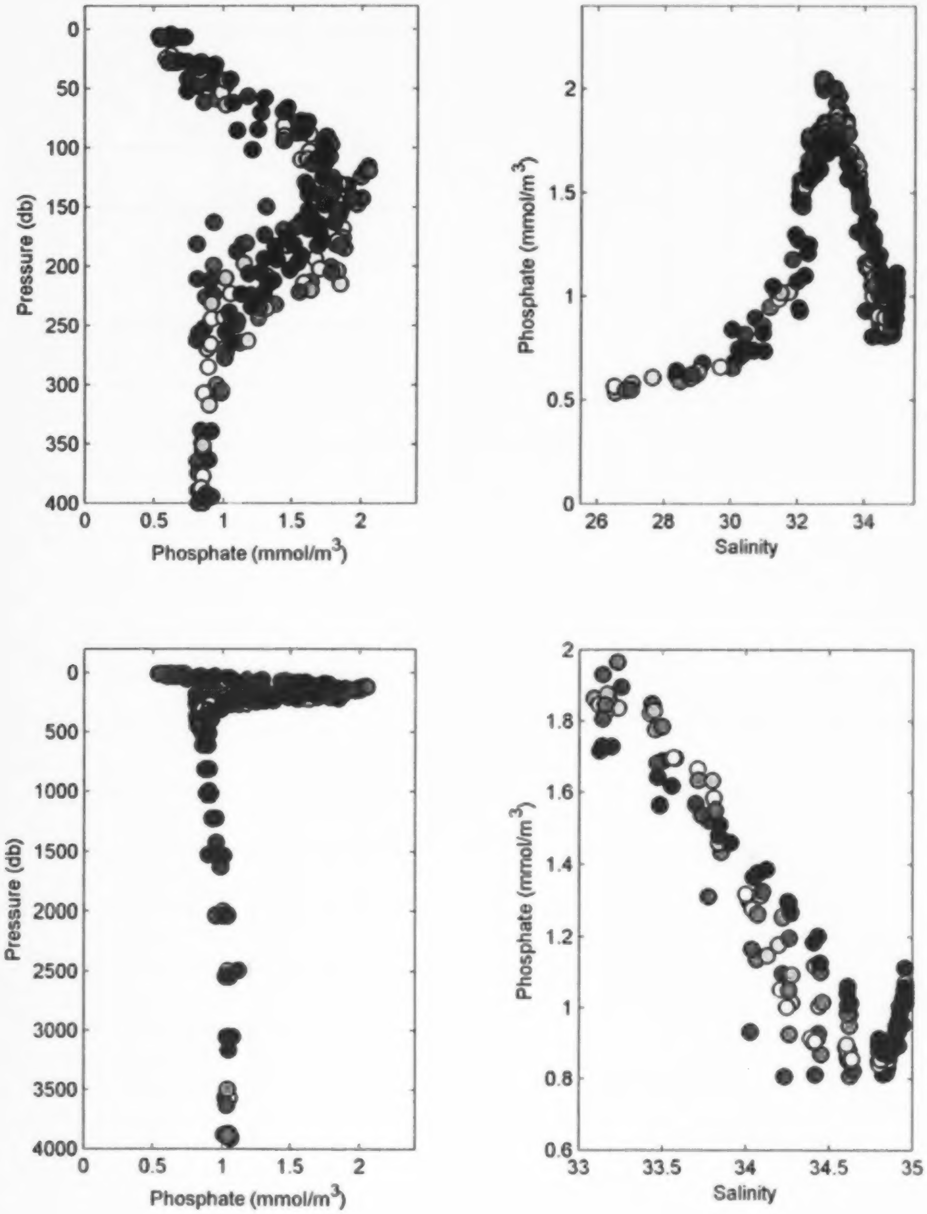
2005-04 Group: West of 145°W, Property: Nitrate and Nitrite



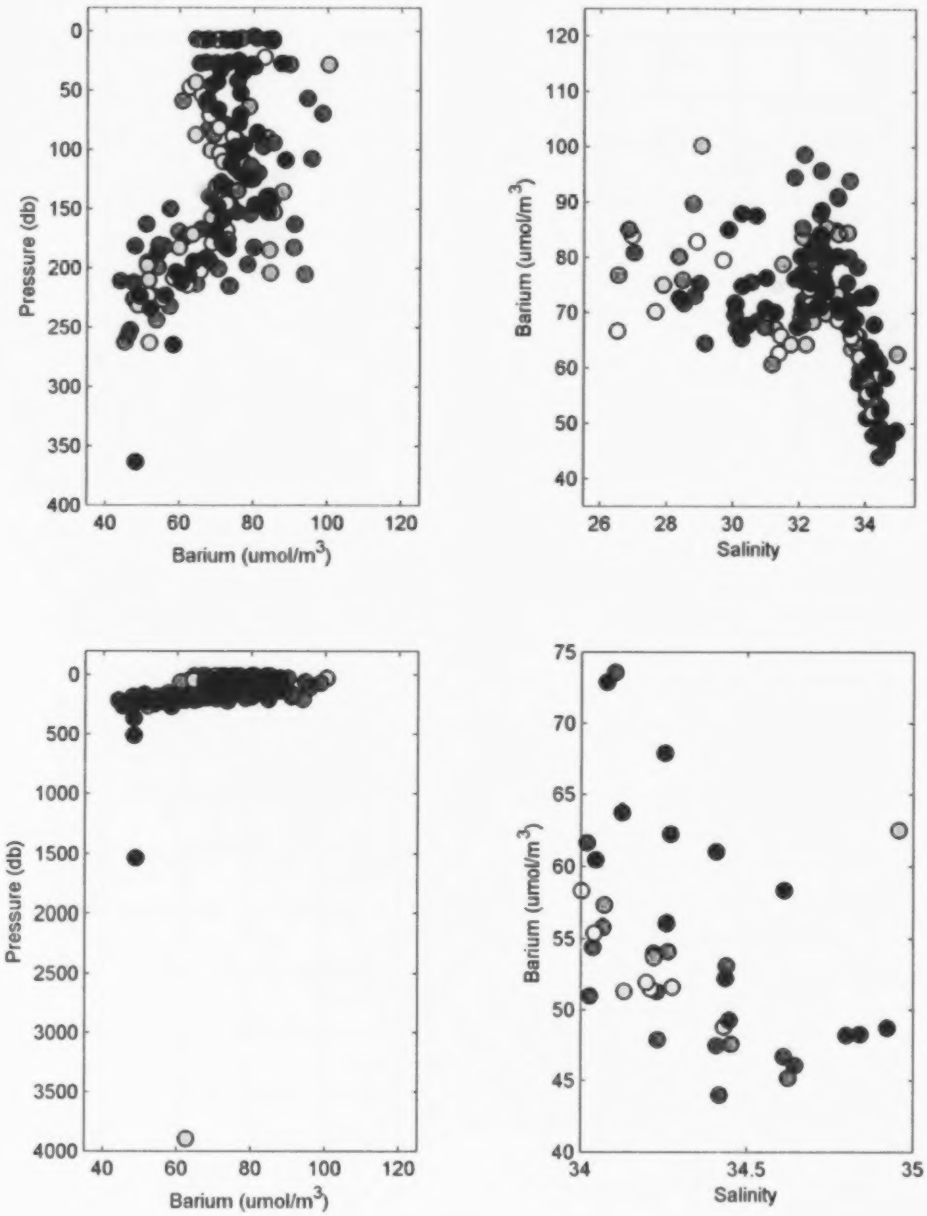
2005-04 Group: West of 145°W, Property: Silicate



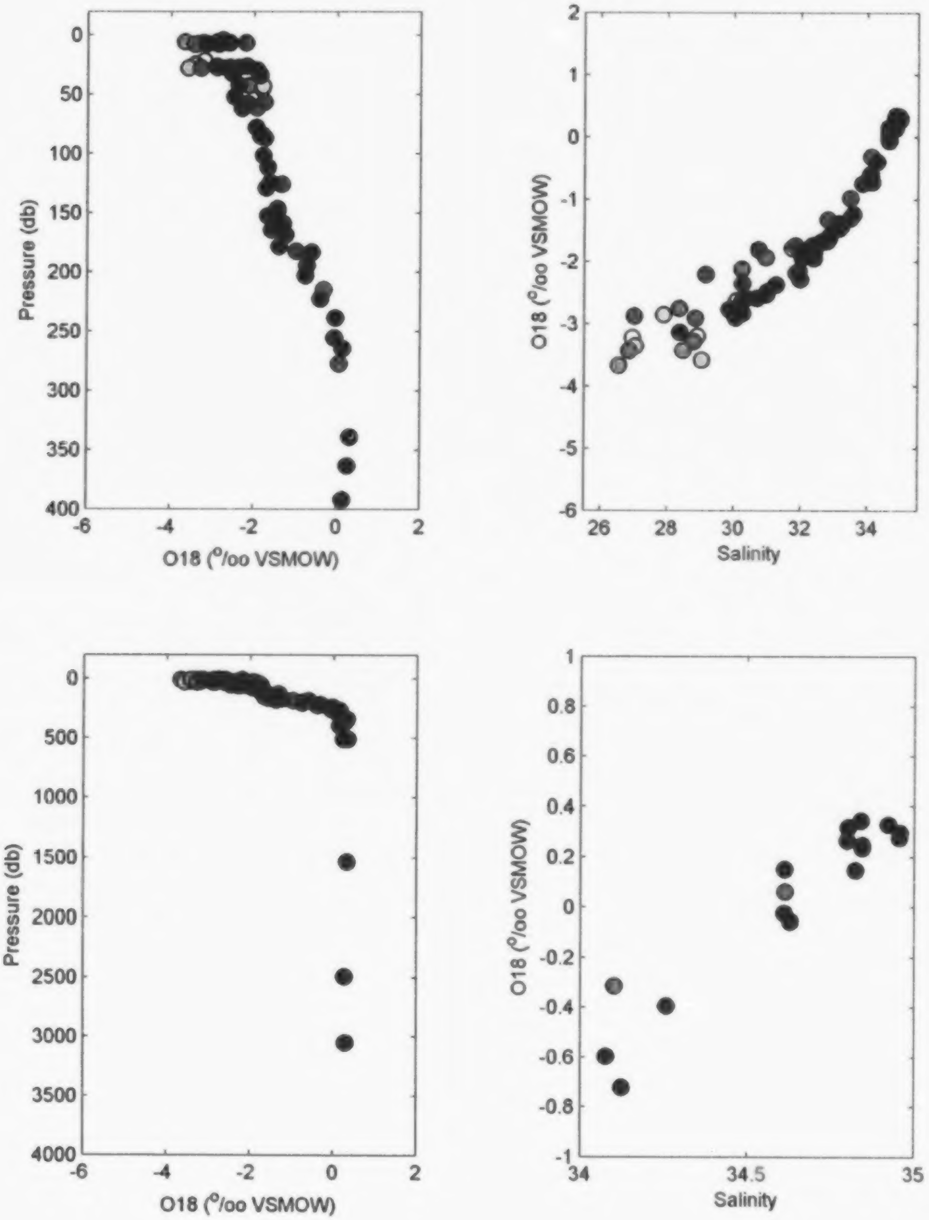
2005-04 Group: West of 145°W, Property: Phosphate



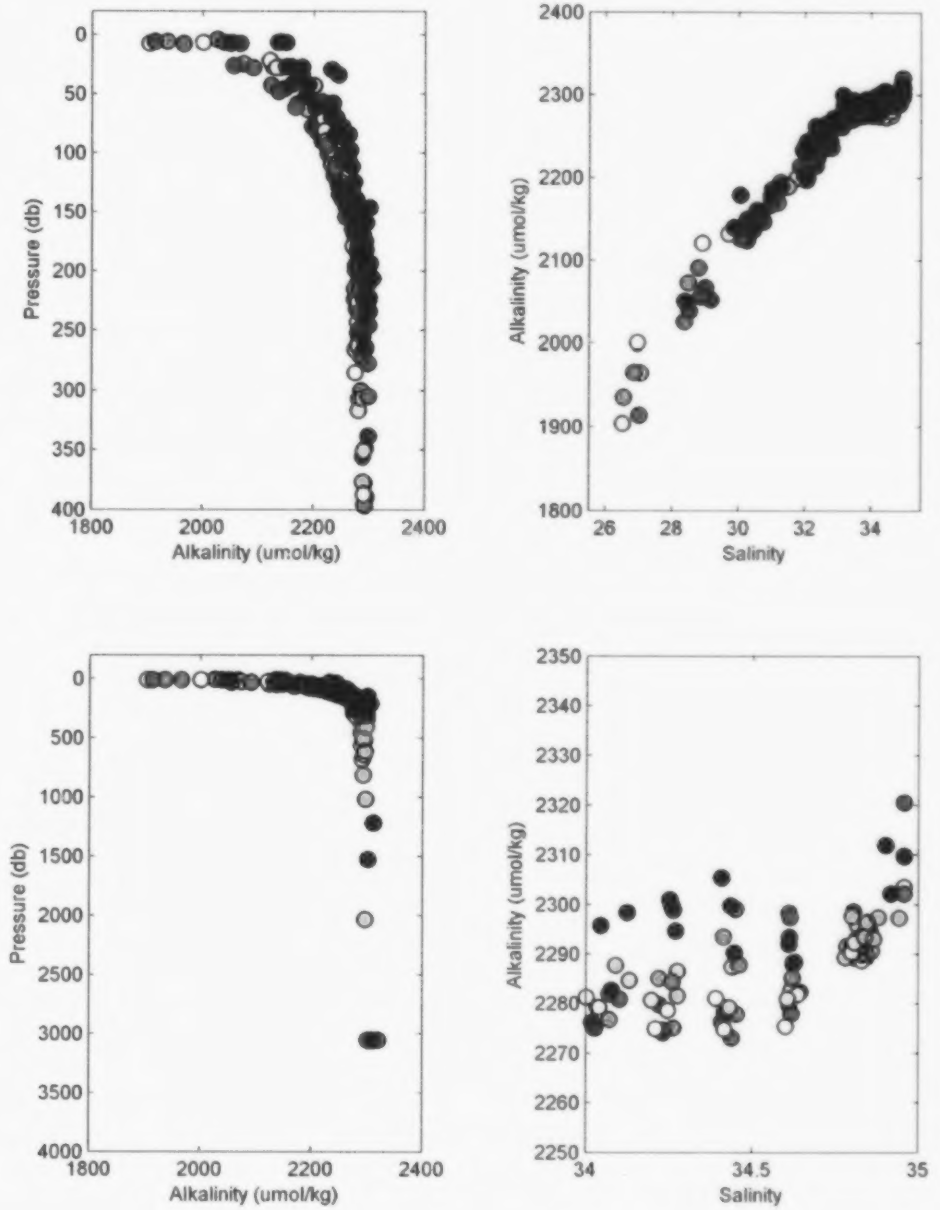
2005-04 Group: West of 145°W, Property: Barium



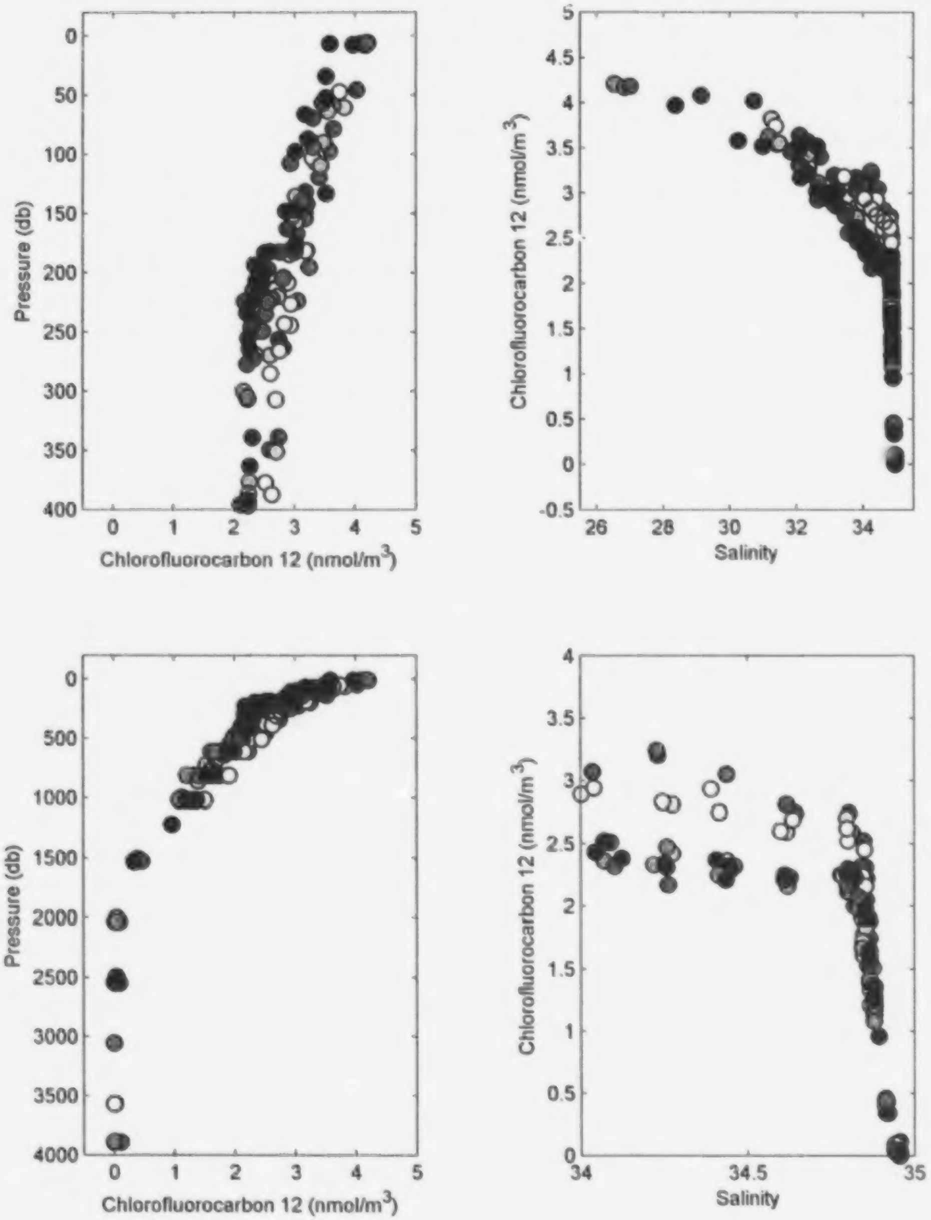
2005-04 Group: West of 145°W, Property: O18



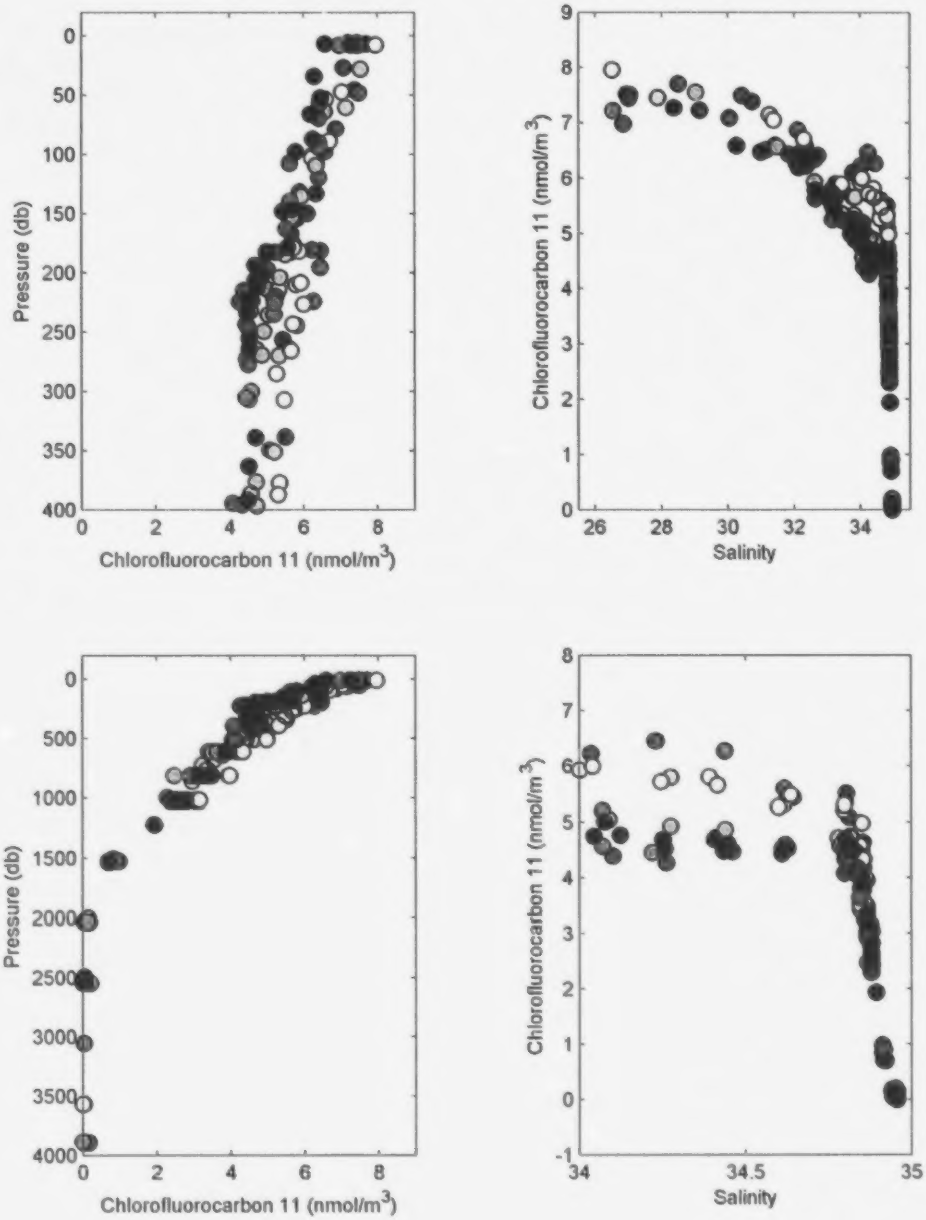
2005-04 Group: West of 145°W, Property: Alkalinity



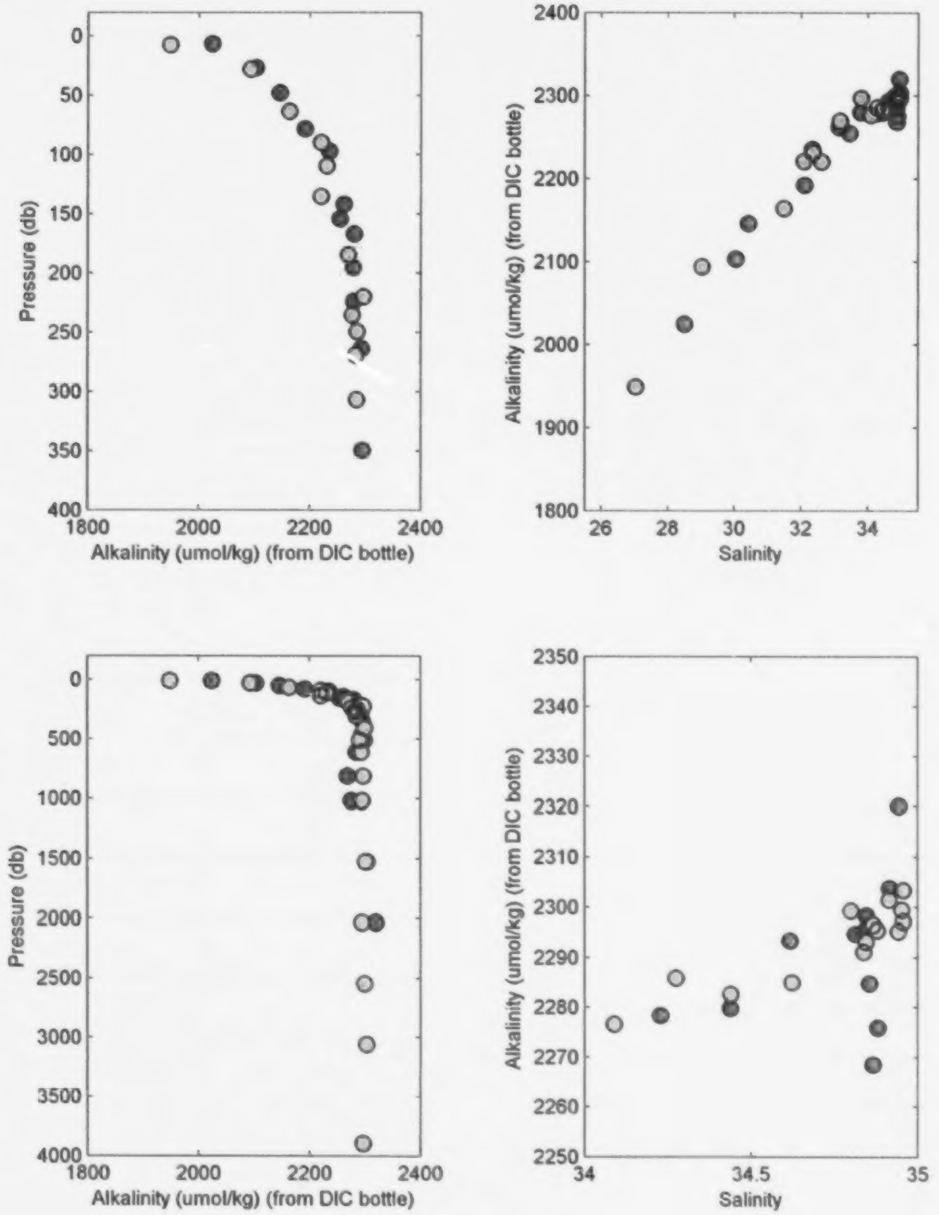
2005-04 Group: West of 145°W, Property: Chlorofluorcarbon-12



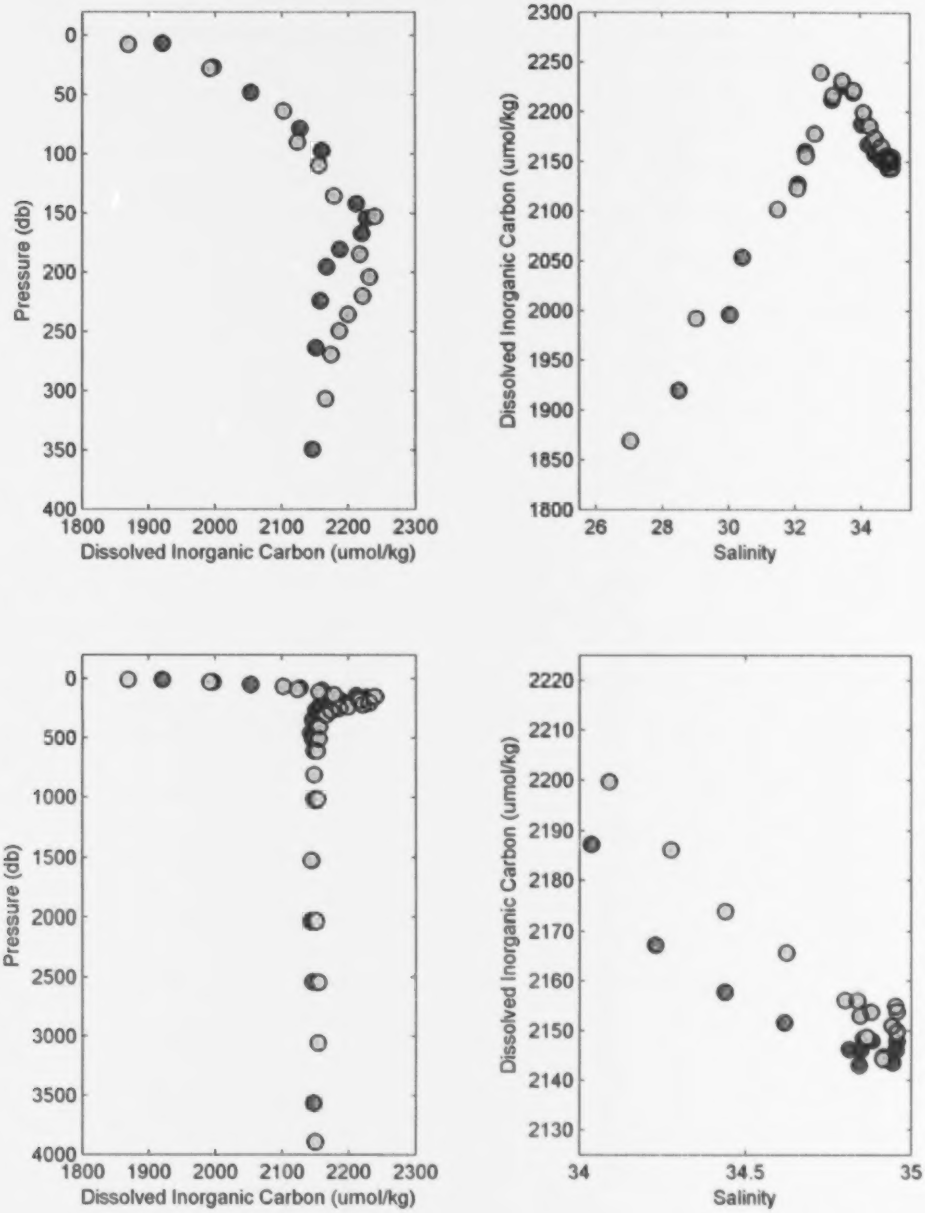
2005-04 Group: West of 145°W, Property: Chlorofluorcarbon-11



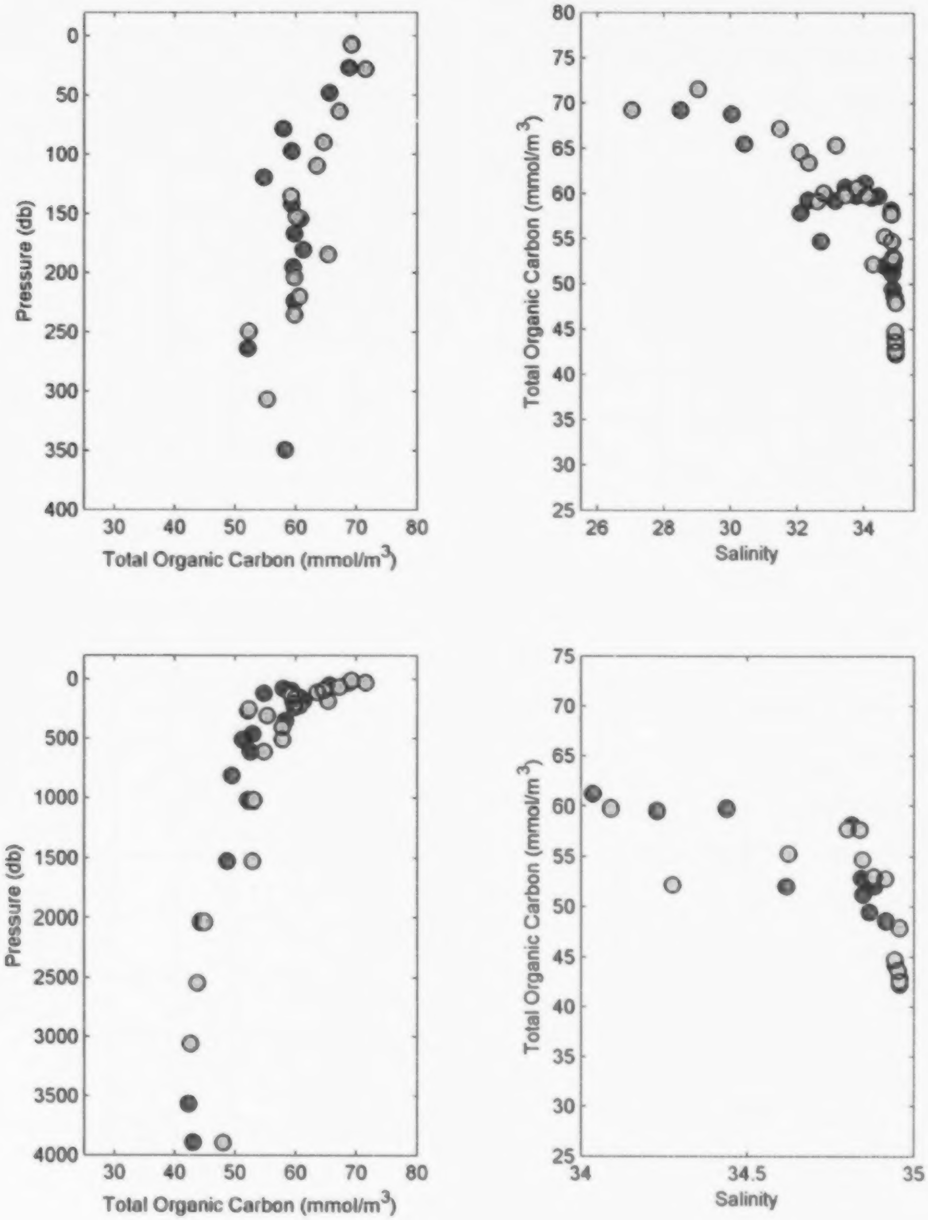
2005-04 Group: West of 145°W, Property: Alkalinity (from DIC bottle)



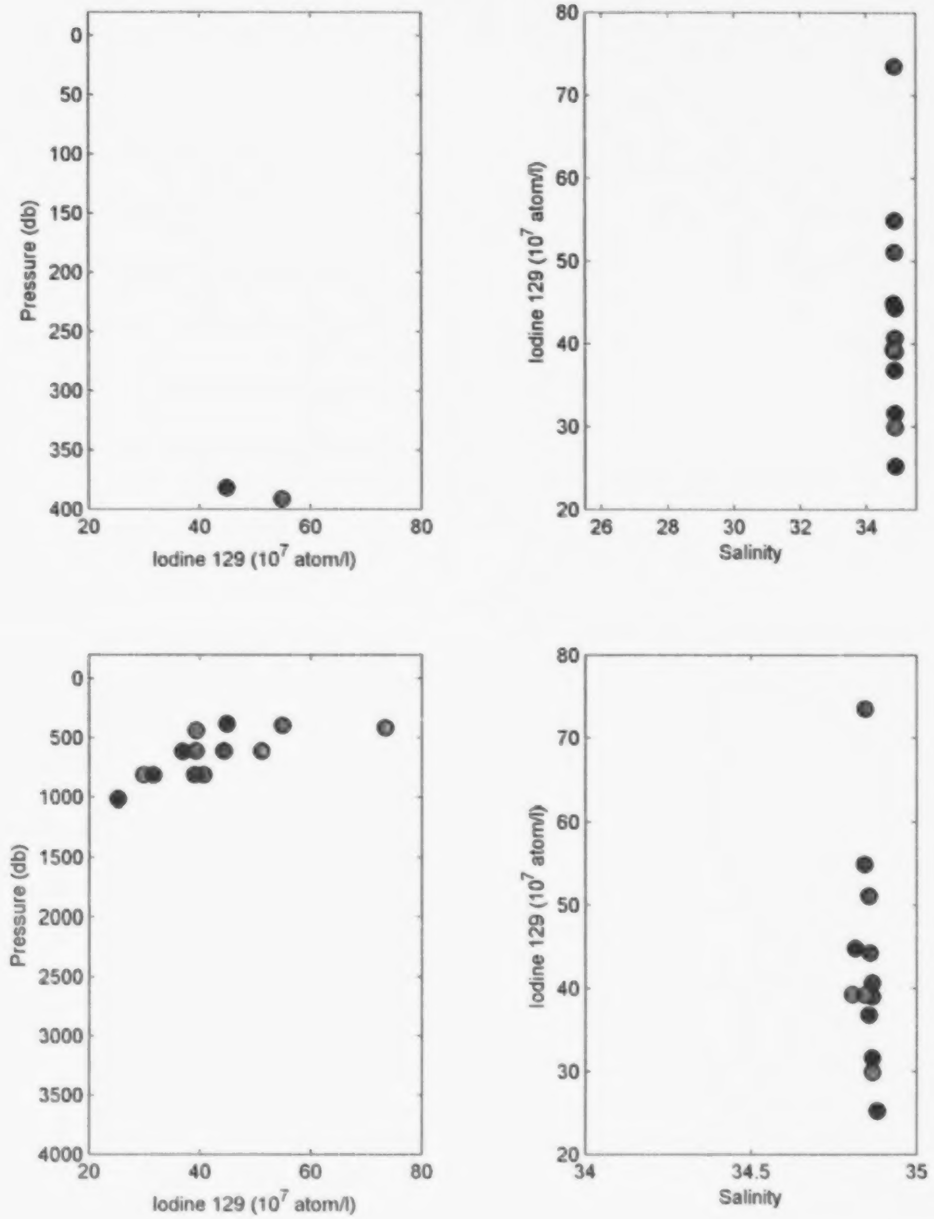
2005-04 Group: West of 145°W, Property: Dissolved Inorganic Carbon



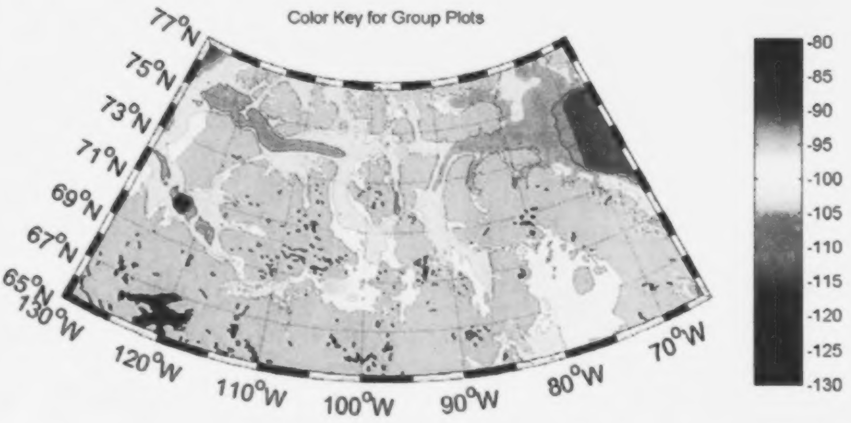
2005-04 Group: West of 145°W, Property: Total Organic Carbon



2005-04 Group: West of 145°W, Property: Iodine-129

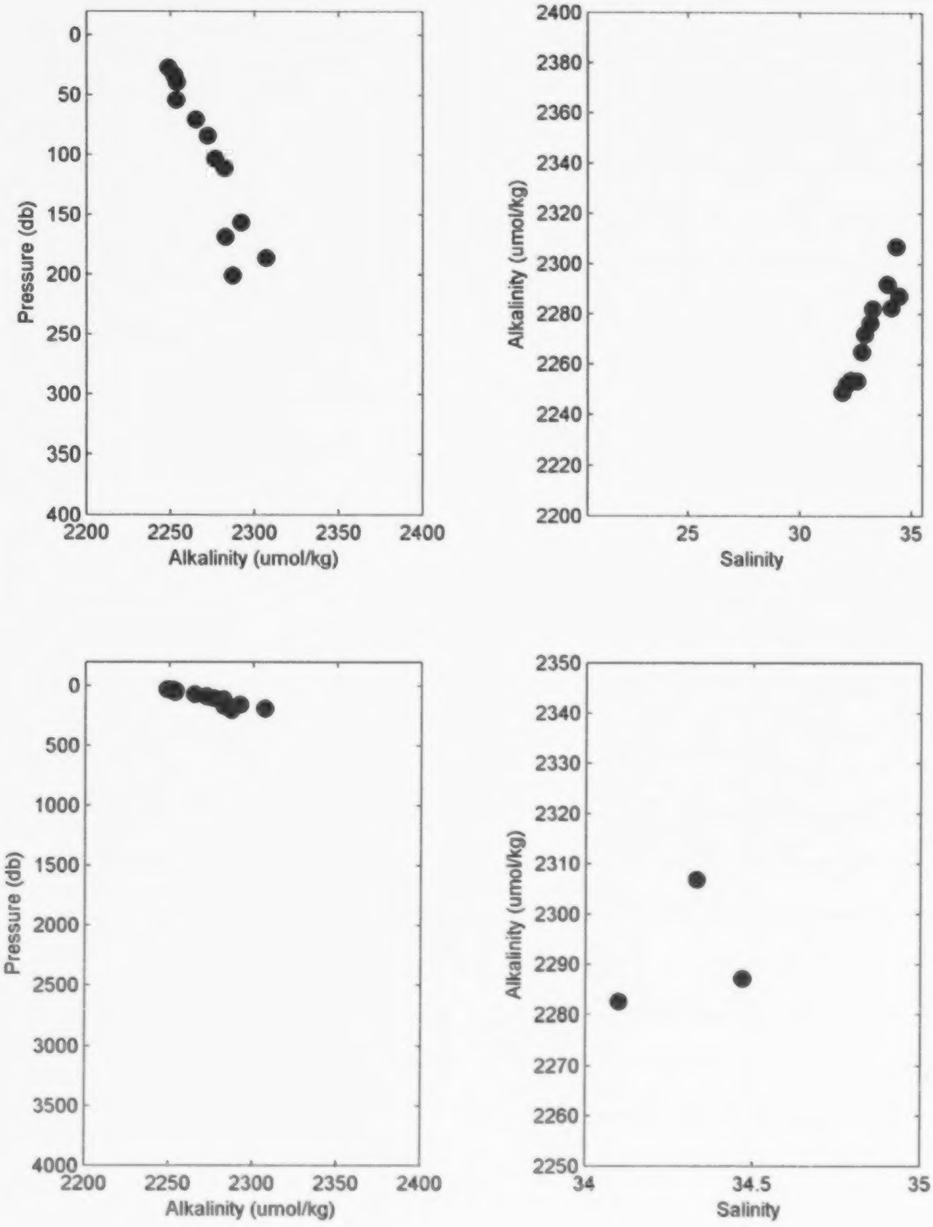


6.2 Casts in the Canadian Archipelago

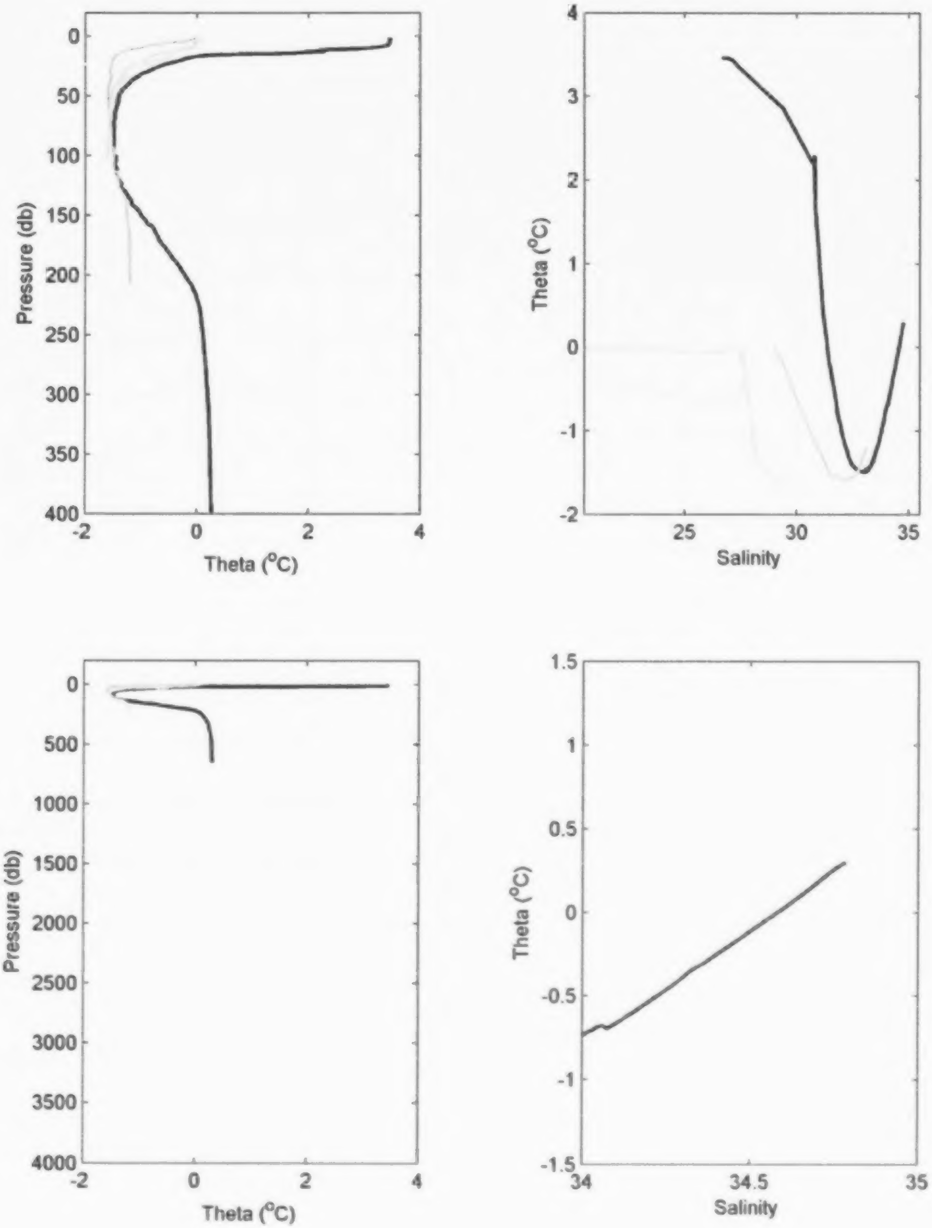


Color Key for Group Plots
77°N
75°N
73°N
71°N
69°N
67°N
65°N
130°W
120°W
110°W
100°W
90°W
80°W
70°W
-80
-85
-90
-95
-100
-105
-110
-115
-120
-125
-130

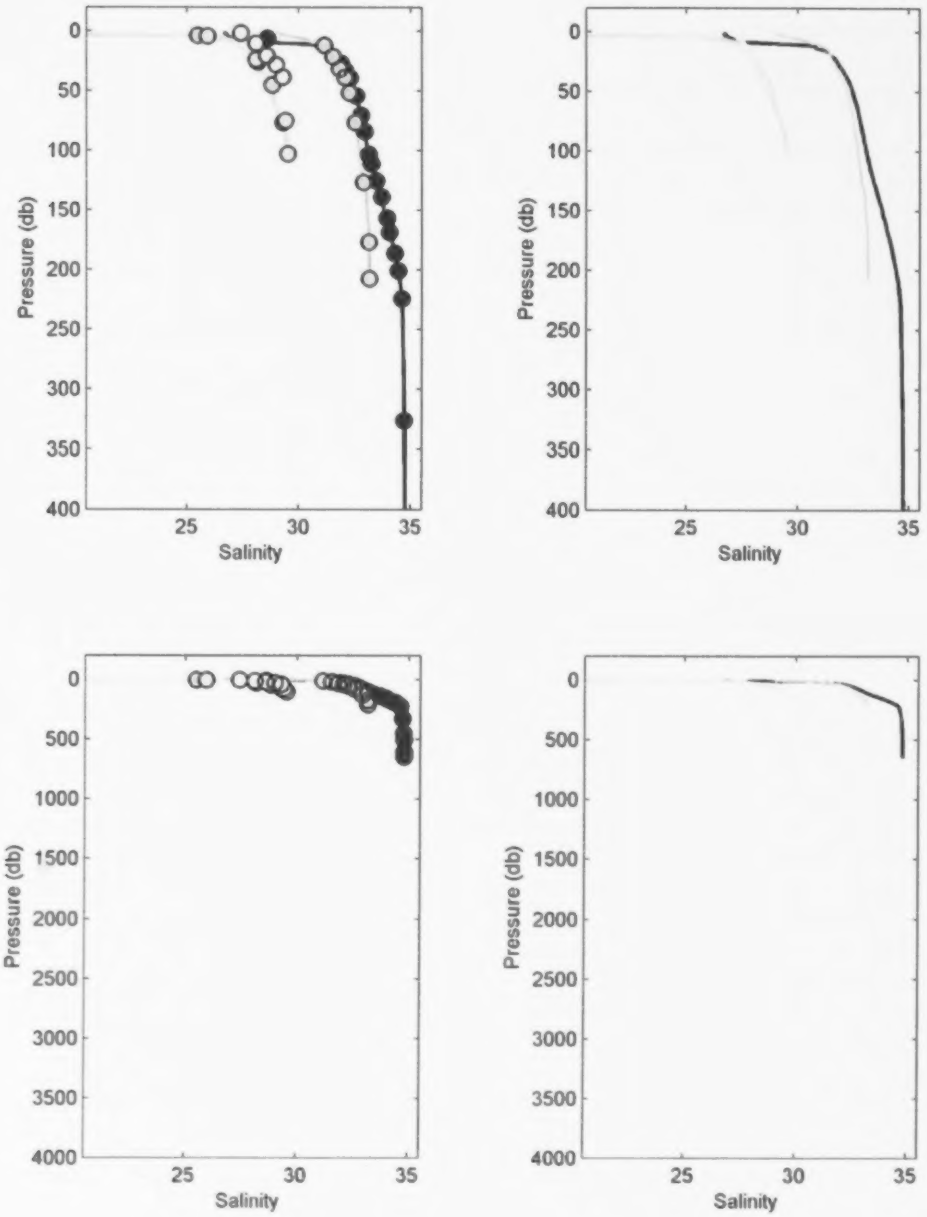
2005-04 Group: Canadian Archipelago, Property: Alkalinity



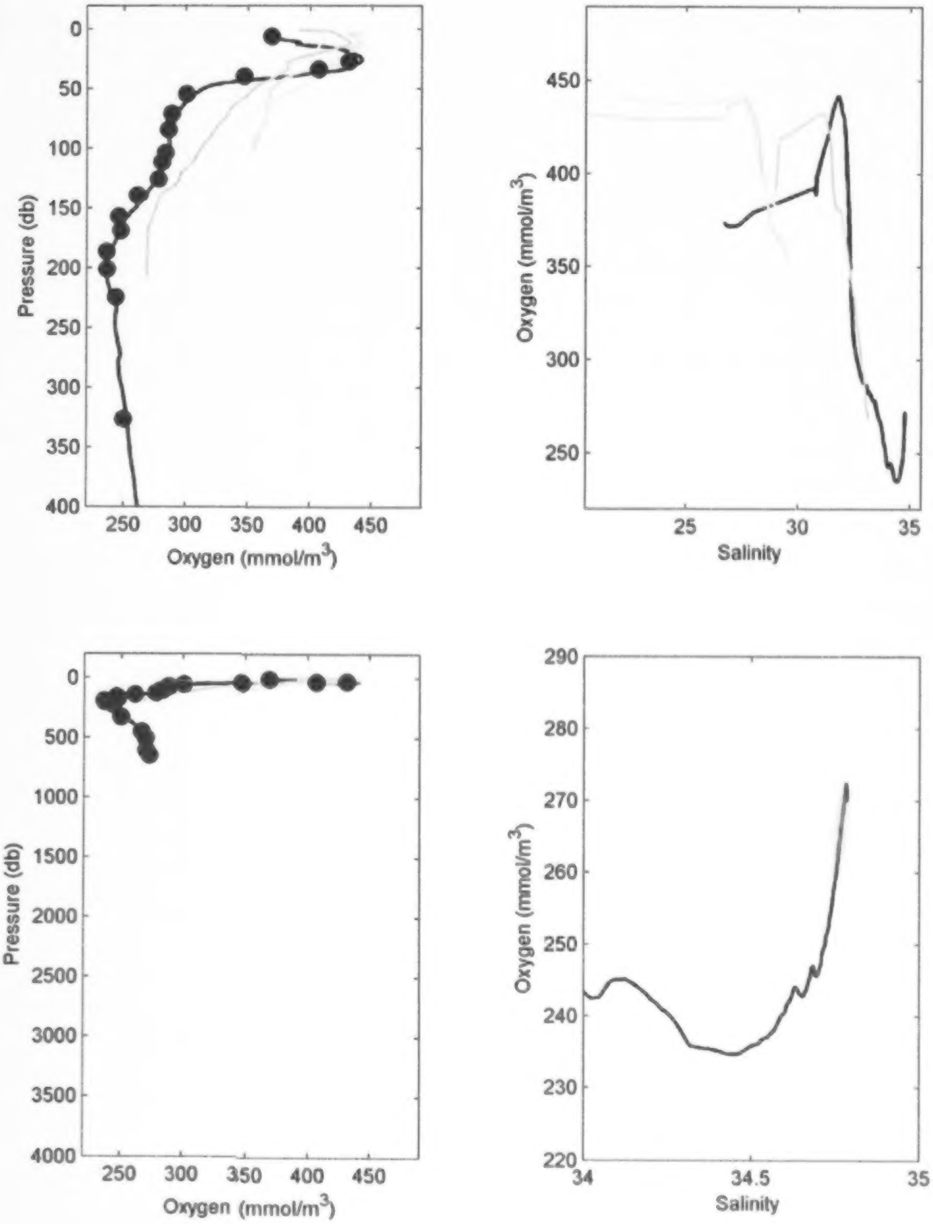
2005-04 Group: Canadian Archipelago, Property: Theta



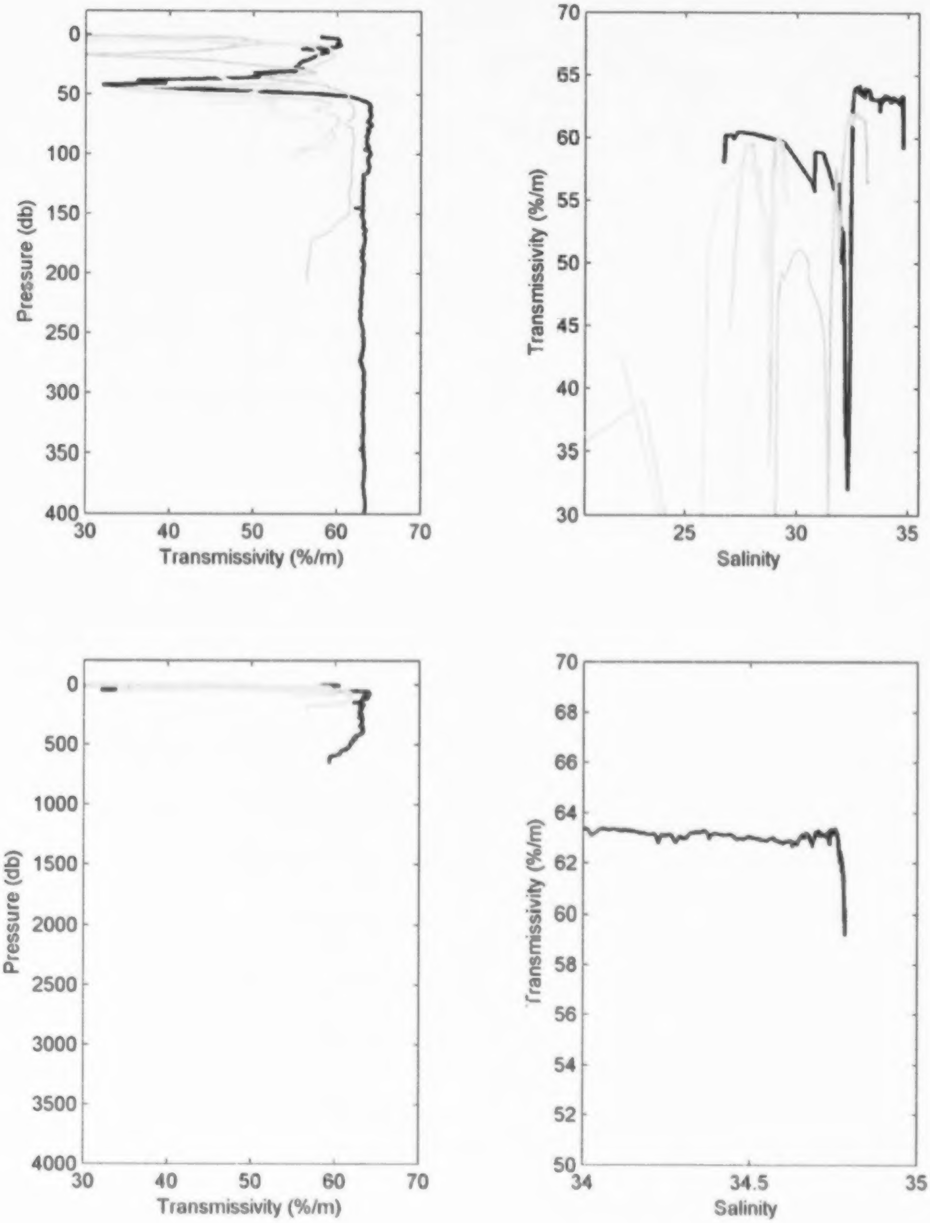
2005-04 Group: Canadian Archipelago, Property: Salinity



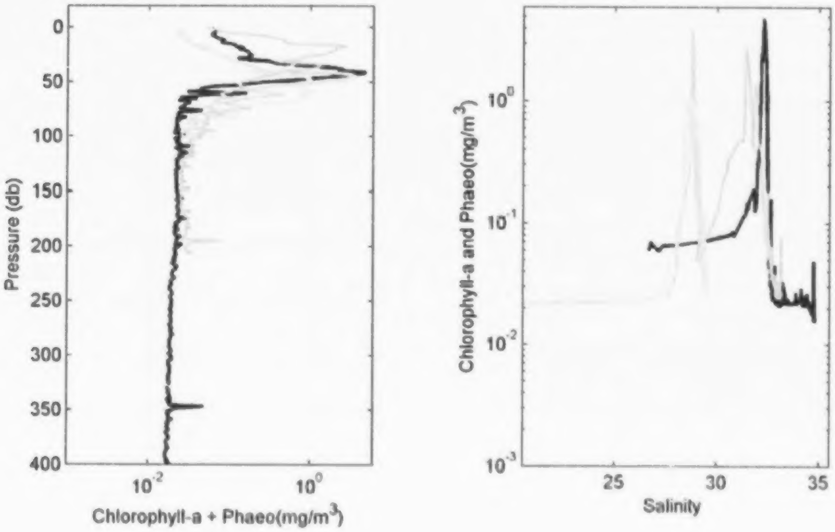
2005-04 Group: Canadian Archipelago, Property: Oxygen



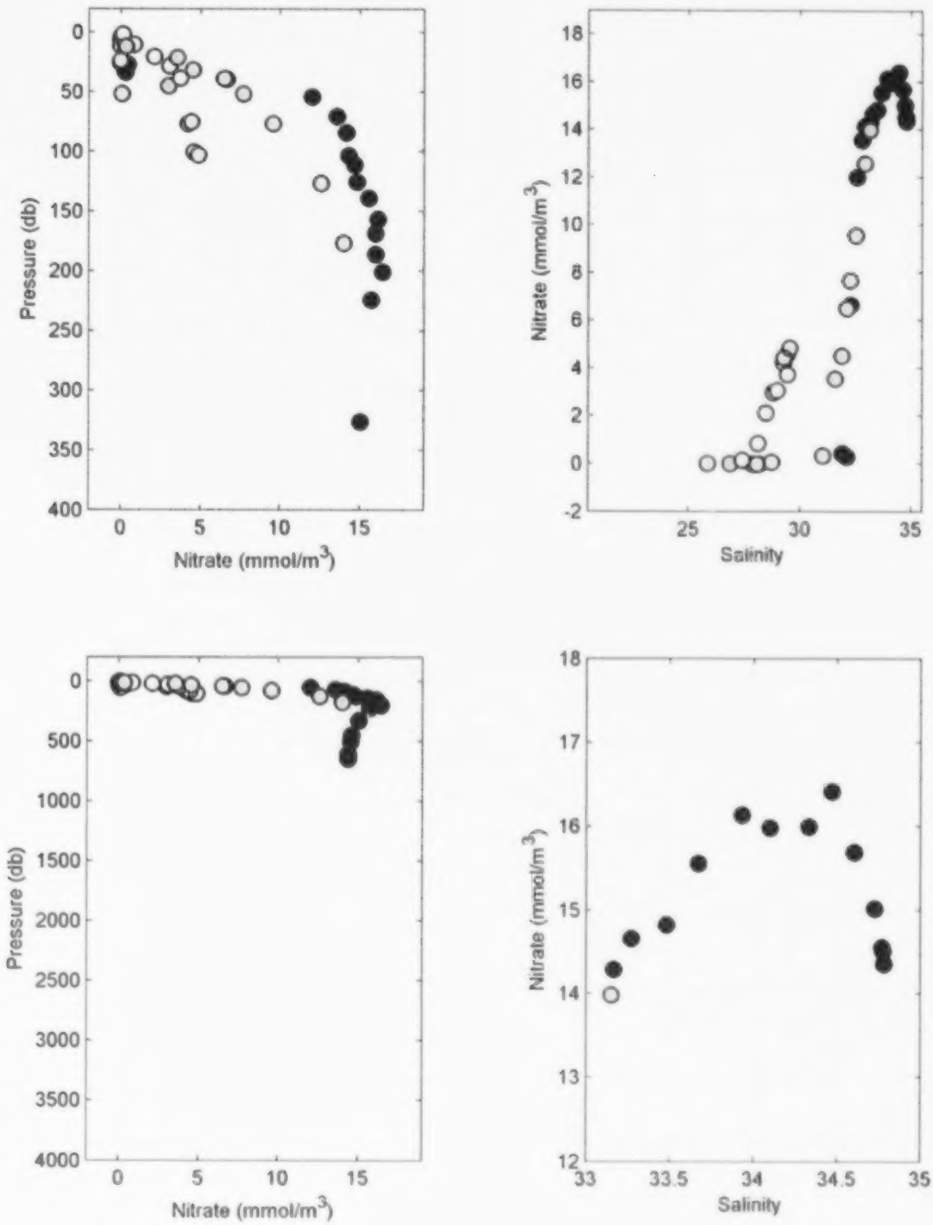
2005-04 Group: Canadian Archipelago, Property: Transmission



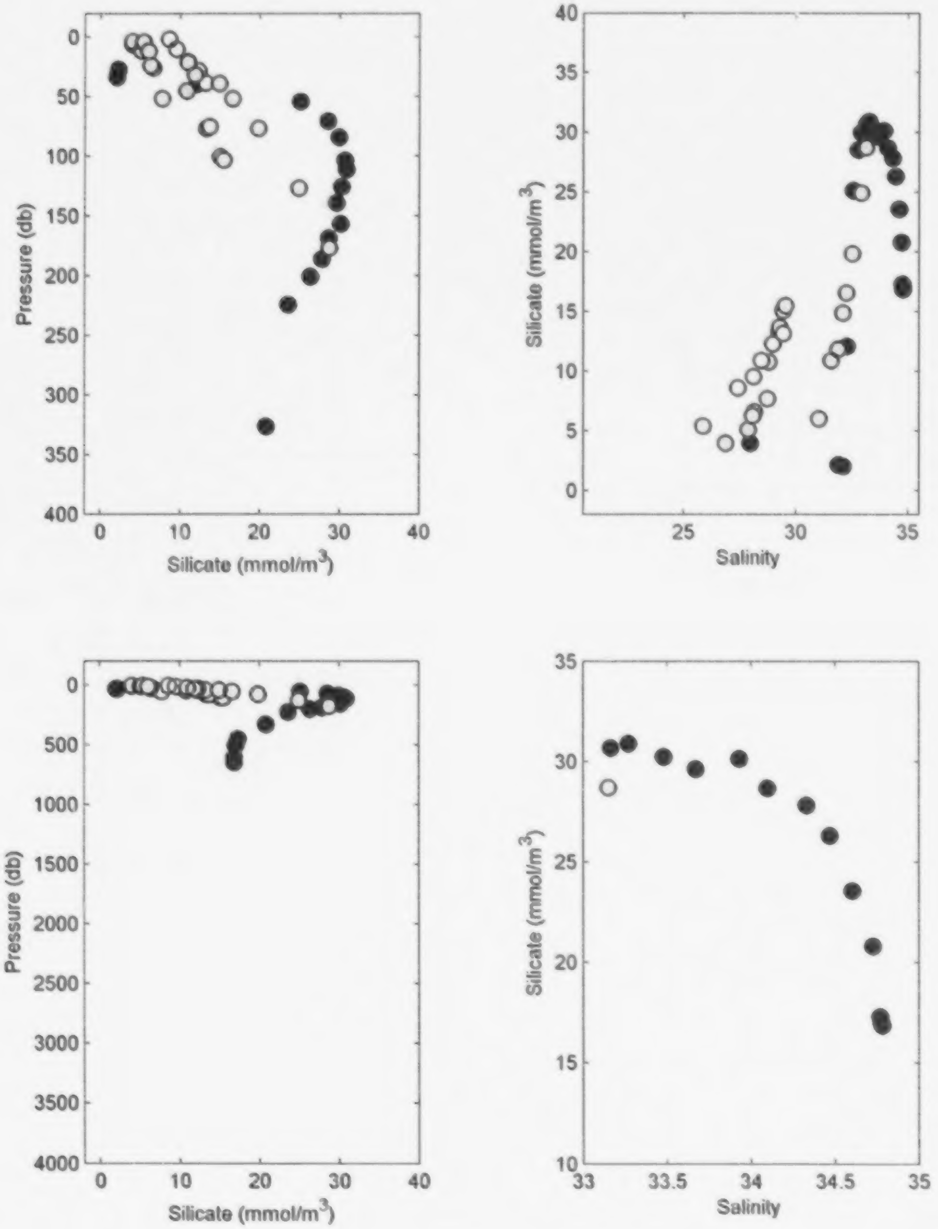
2005-04 Group: Canadian Archipelago, Property: Combined Chlorophyll-a and Phaeopigment



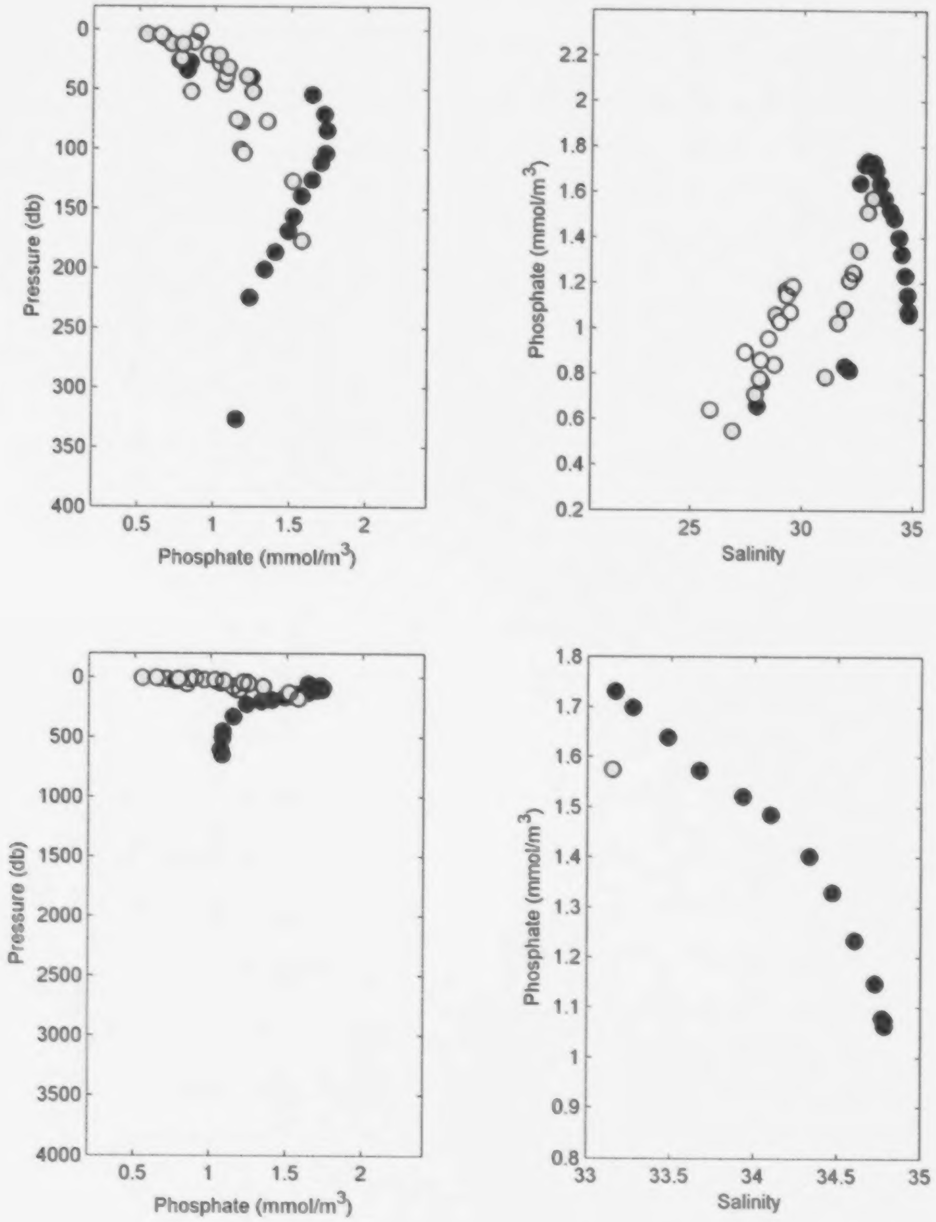
2005-04 Group: Canadian Archipelago, Property: Nitrate and Nitrite



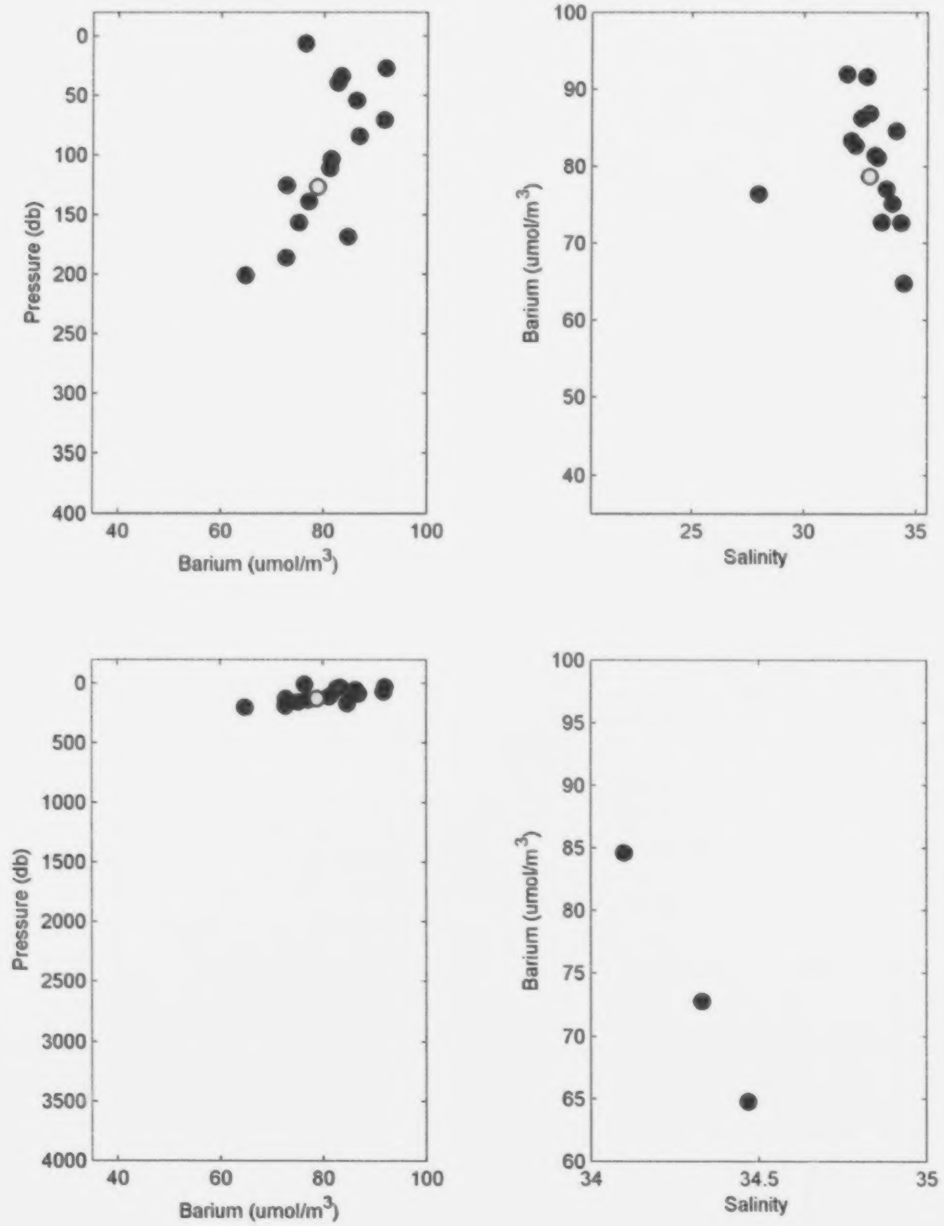
2005-04 Group: Canadian Archipelago, Property: Silicate



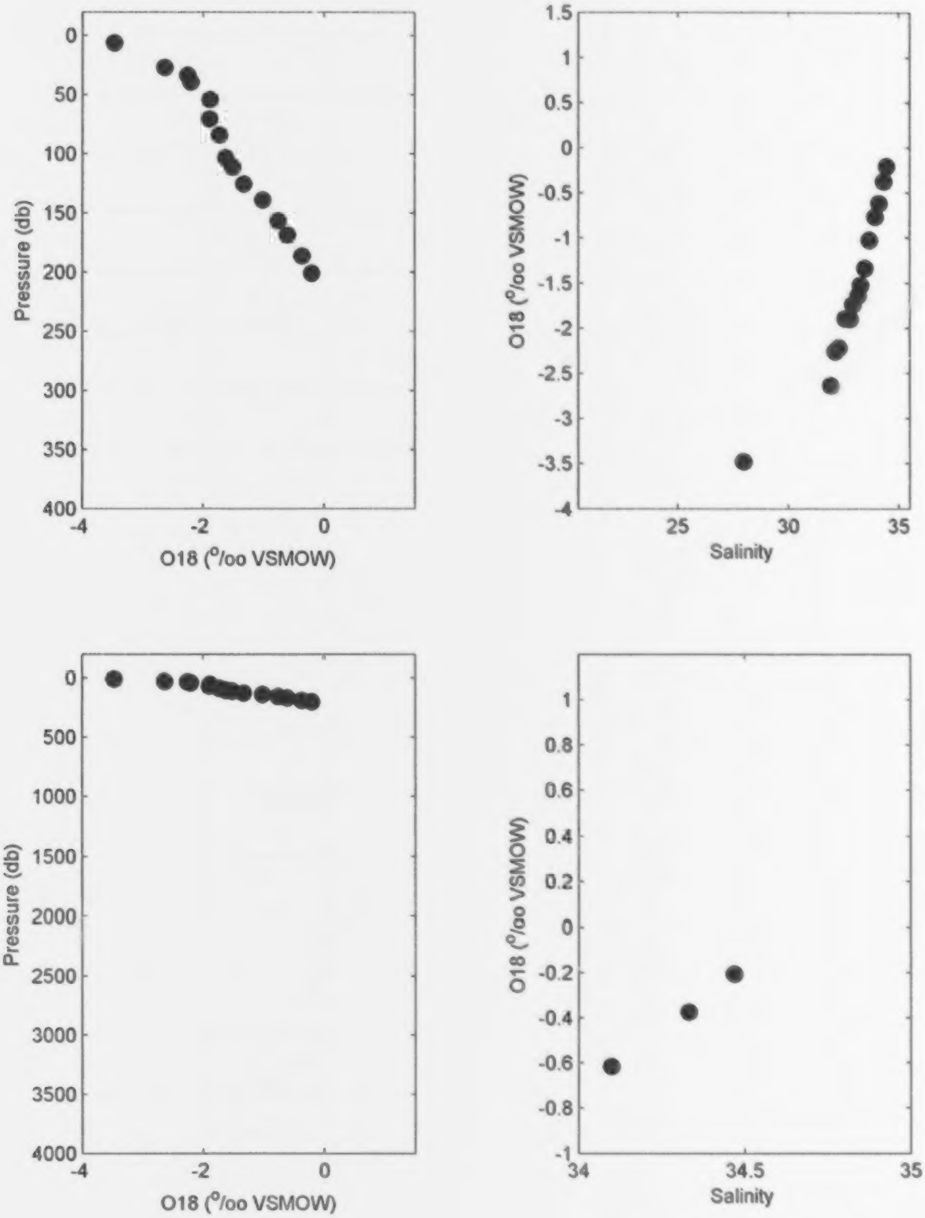
2005-04 Group: Canadian Archipelago, Property: Phosphate



2005-04 Group: Canadian Archipelago, Property: Barium

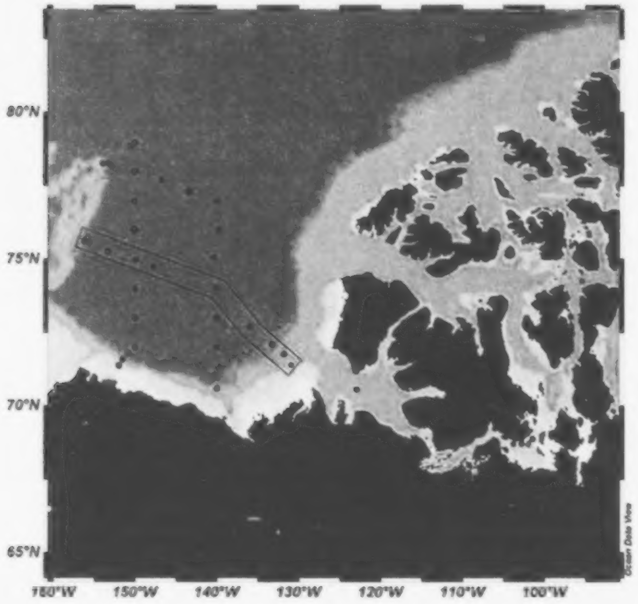


2005-04 Group: Canadian Archipelago, Property: O18

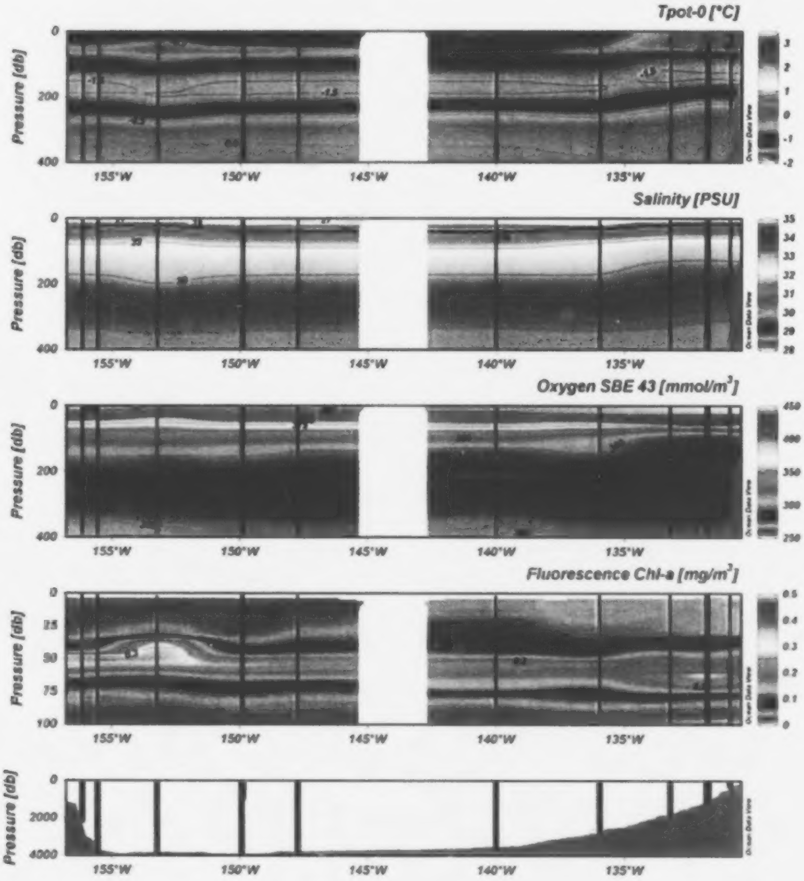


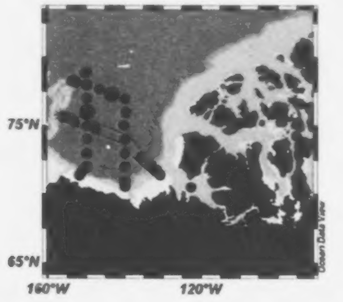
7. SECTION PLOTS

CTD Map: 75 to 71°N Section

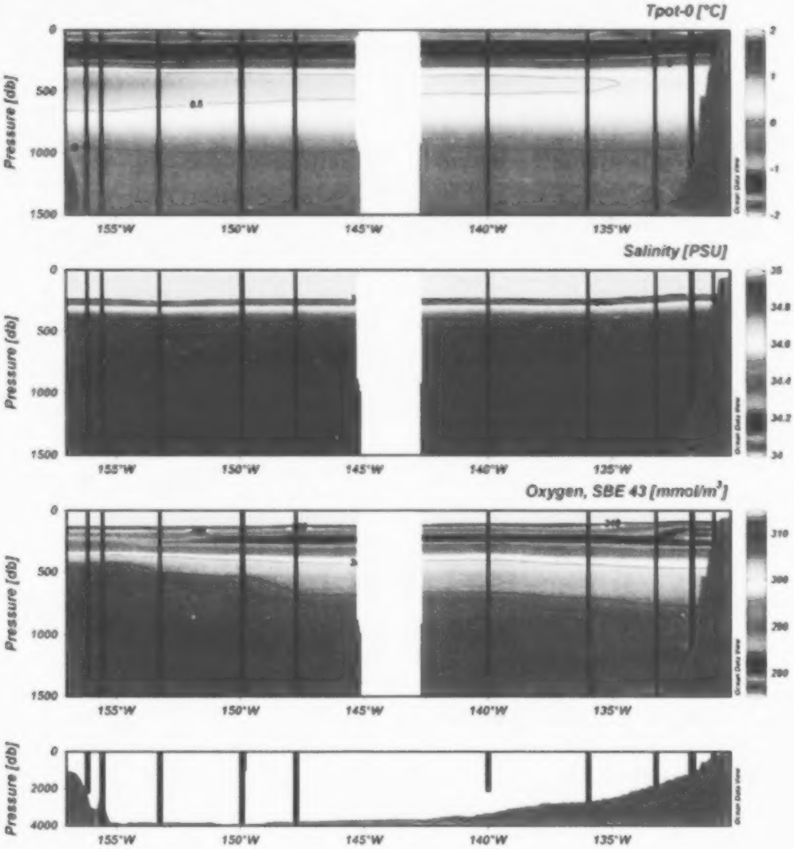

80°N
75°N
70°N
65°N
160°W
150°W
140°W
130°W
120°W
110°W
100°W
Ocean Data View

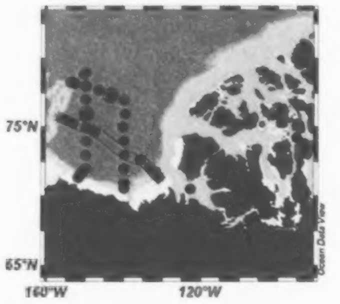
75 to 71°N Section, 0 to 400 db, CTD Data



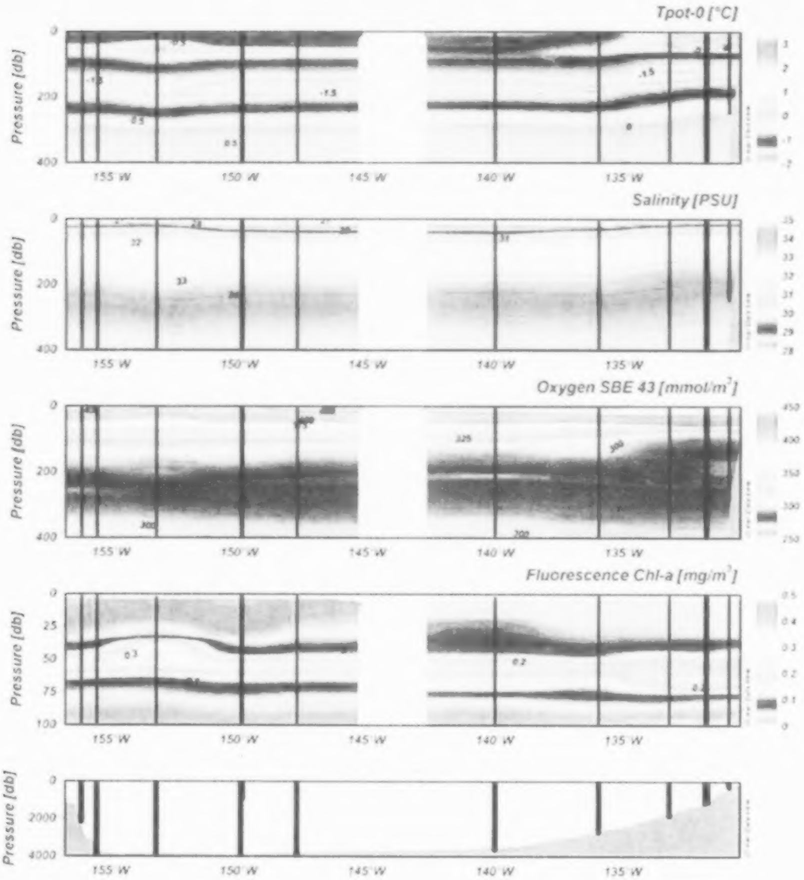

75°N
65°N
160°W
120°W
Ocean Data View

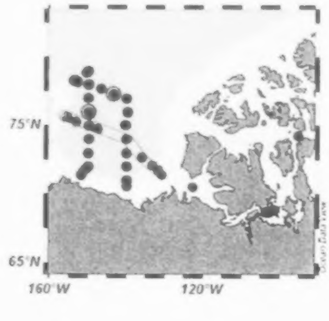
75 to 71°N Section, 0 to 1500 db, CTD Data



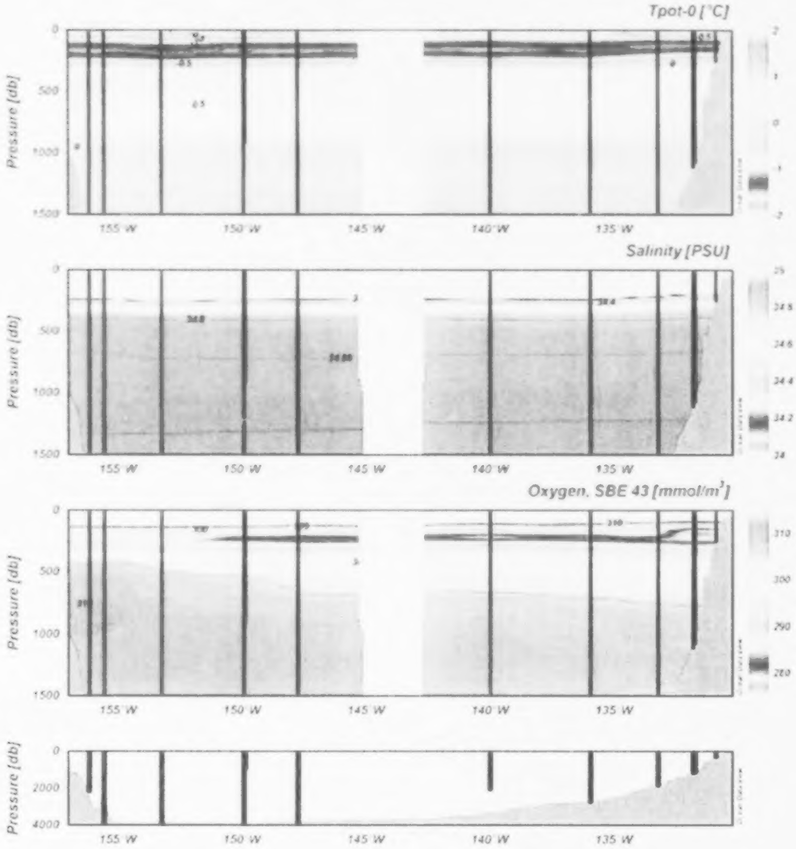

75°N
65°N
160°W
120°W
Ocean Data View

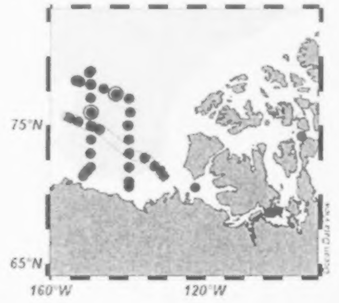
75 to 71°N Section, 0 to 400 db, CTD Data



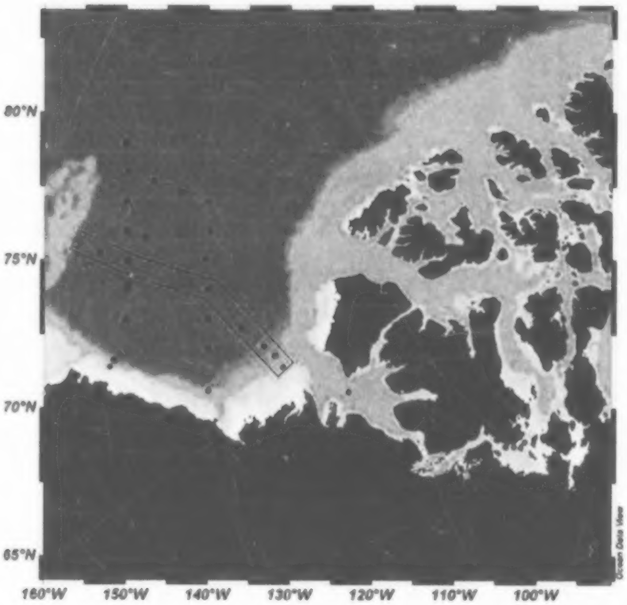

75°N
65°N
160°W
120°W

75 to 71°N Section, 0 to 1500 db, CTD Data

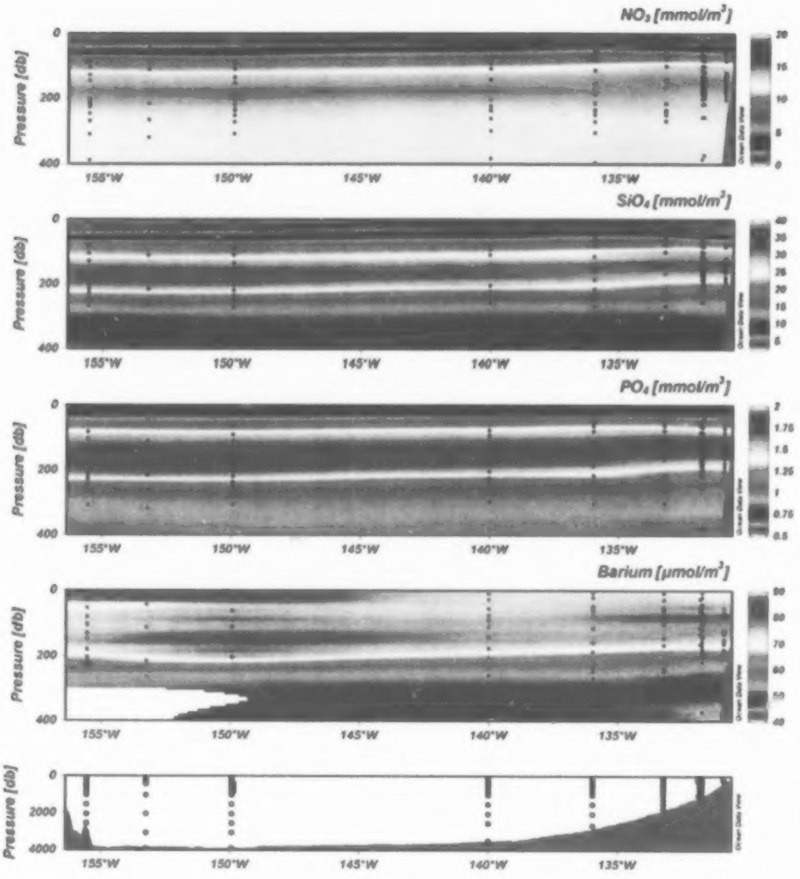


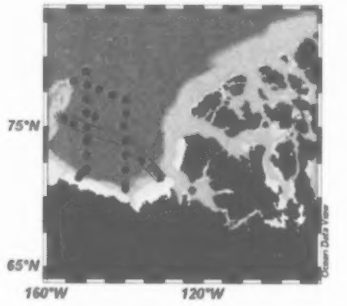

75°N
65°N
160°W
120°W
Ocean Data View

Chemistry Map: 75 to 71°N Section

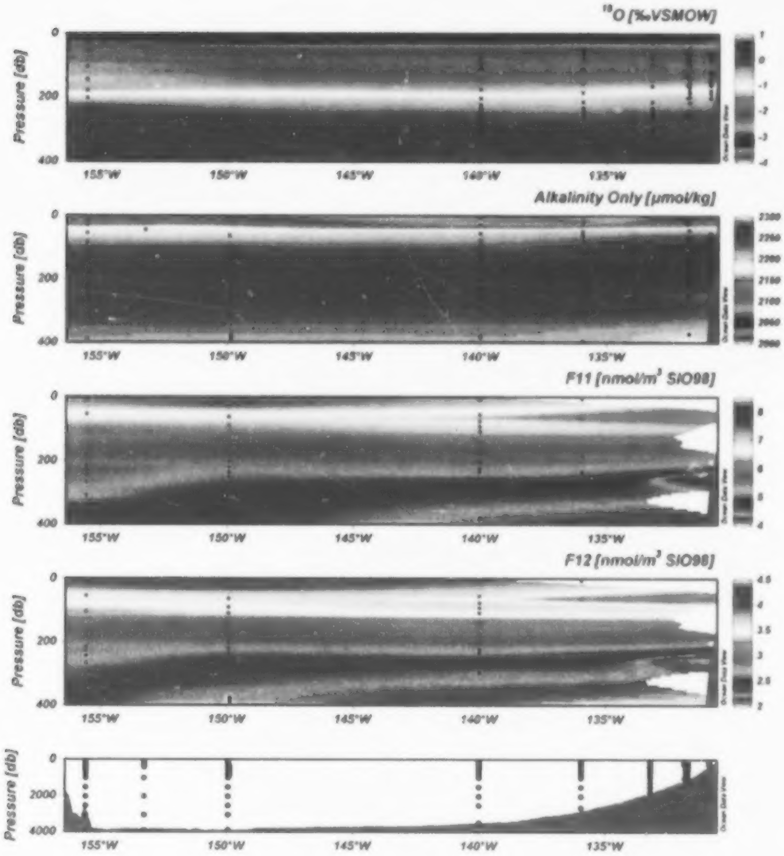

80°N
75°N
70°N
65°N
160°W
150°W
140°W
130°W
120°W
110°W
100°W
Ocean Data View

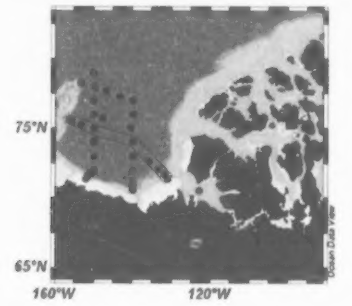
75 to 71°N Section, 0 to 400 db, Chemistry Data


NO₃ [mmol/m³]
SiO₄ [mmol/m³]
PO₄ [mmol/m³]
Barium [µmol/m³]
Pressure [db]
0
200
400
2000
4000
155°W
150°W
145°W
140°W
135°W
20
15
10
5
0
40
35
30
25
20
15
10
5
2
1.75
1.5
1.25
1
0.75
0.5
90
80
70
60
50
40
Ocean Data View


75°N
65°N
160°W
120°W
Ocean Data View

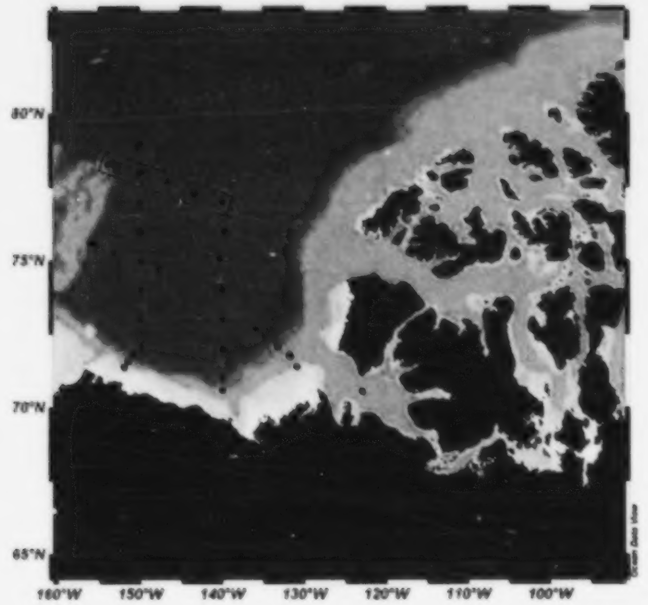
75 to 71°N Section, 0 to 400 db, Chemistry Data



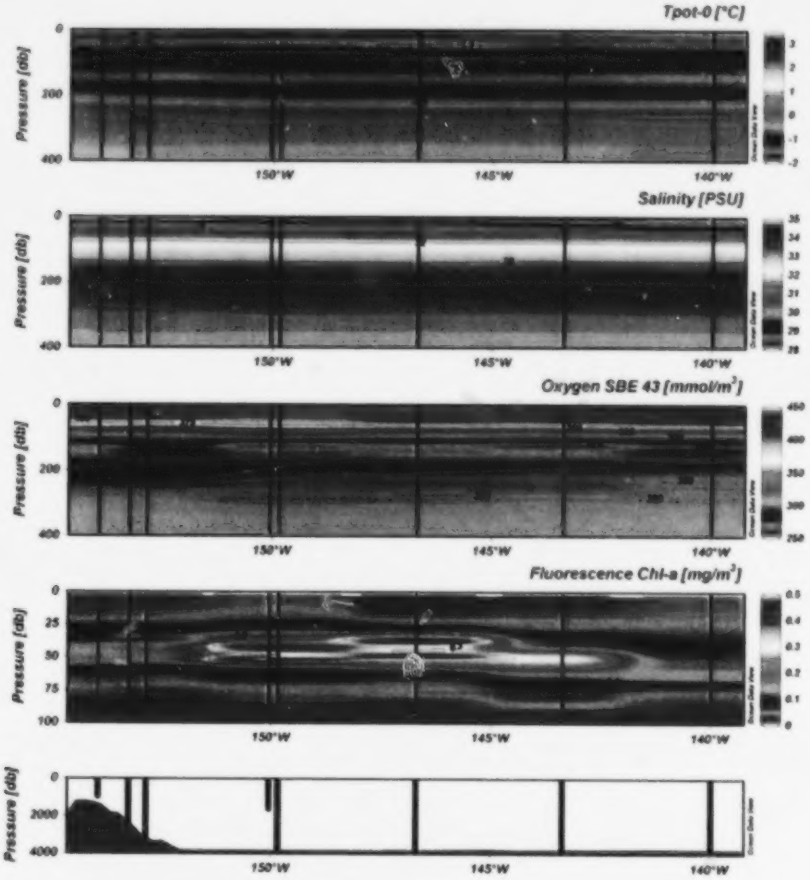


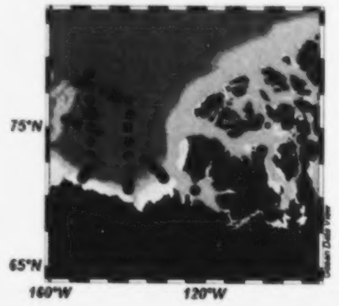
75°N
65°N
160°W
120°W
Ocean Data View

CTD Map: 77 to 76°N Section

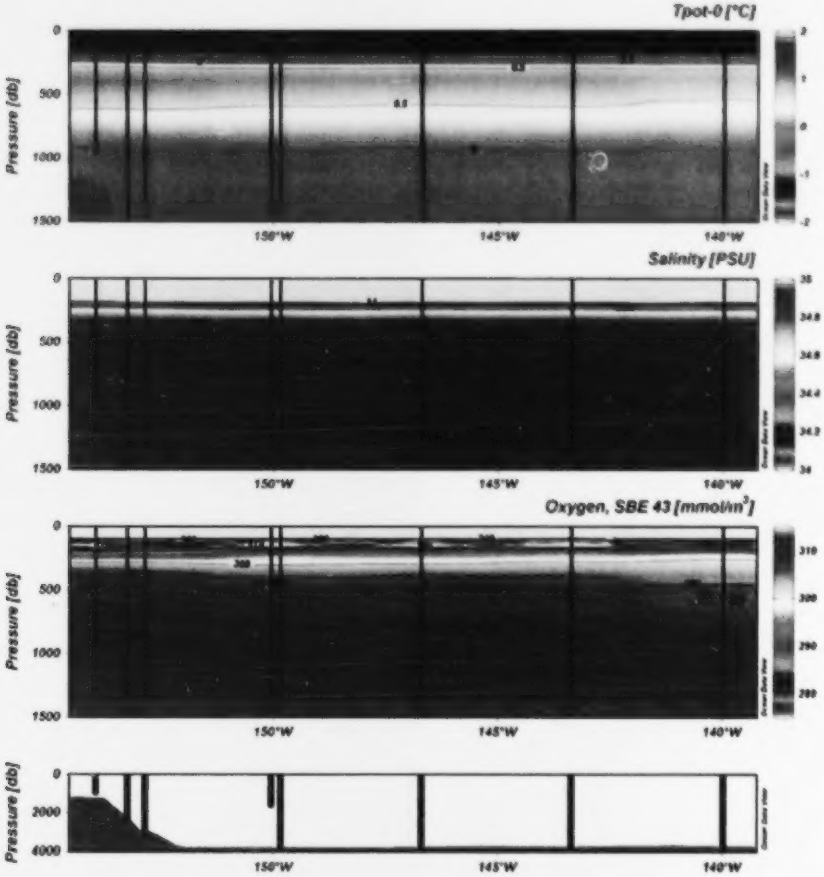

80°N
75°N
70°N
65°N
160°W
150°W
140°W
130°W
120°W
110°W
100°W
Ocean Data View

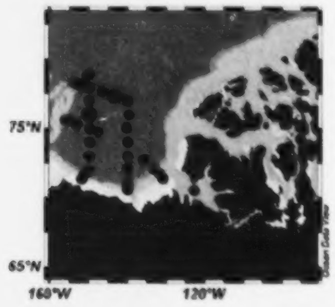
77 to 76°N Section, 0 to 400 db, CTD




75°N
65°N
160°W
120°W
Ocean Data View

77 to 76°N Section, 0 to 1500 db, CTD




75°N
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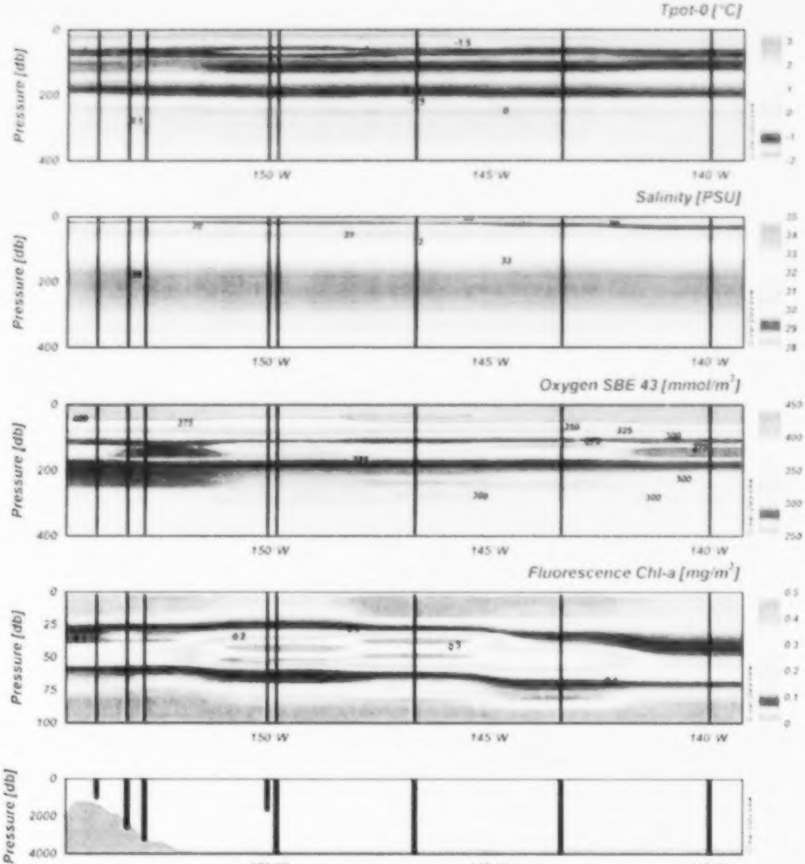
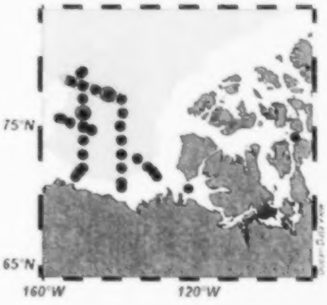
160°W
120°W
Ocean Data View

77 to 76°N Section, 0 to 400 db, CTD

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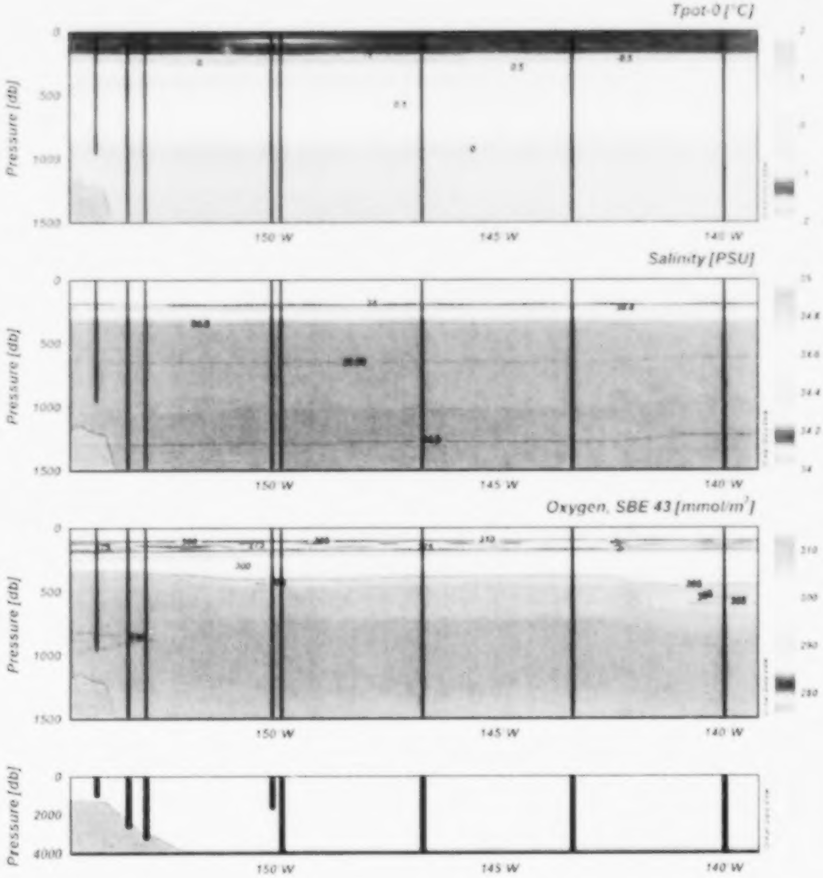
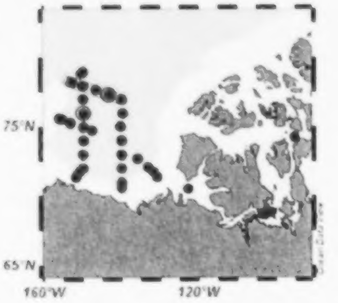
77 to 76°N Section, 0 to 1500 db, CTD

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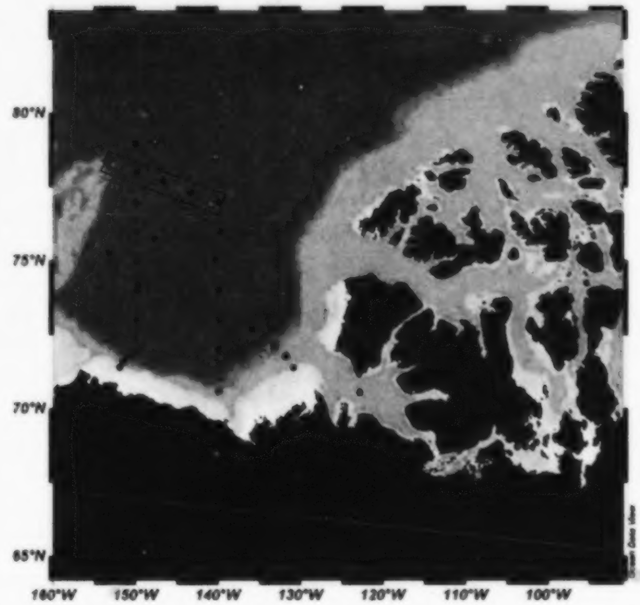
160°W
120°W

Chemistry Map: 77 to 76°N Section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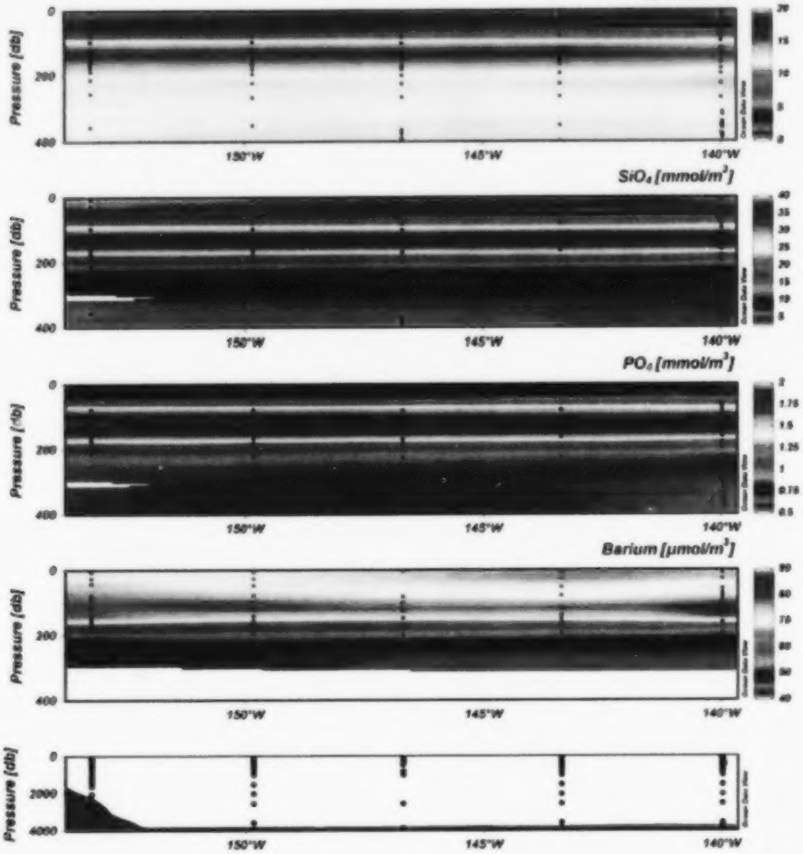
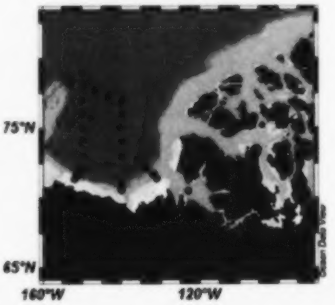
110°W
100°W
Ocean Data View

77 to 76°N Section, 0 to 400 db, Chemistry

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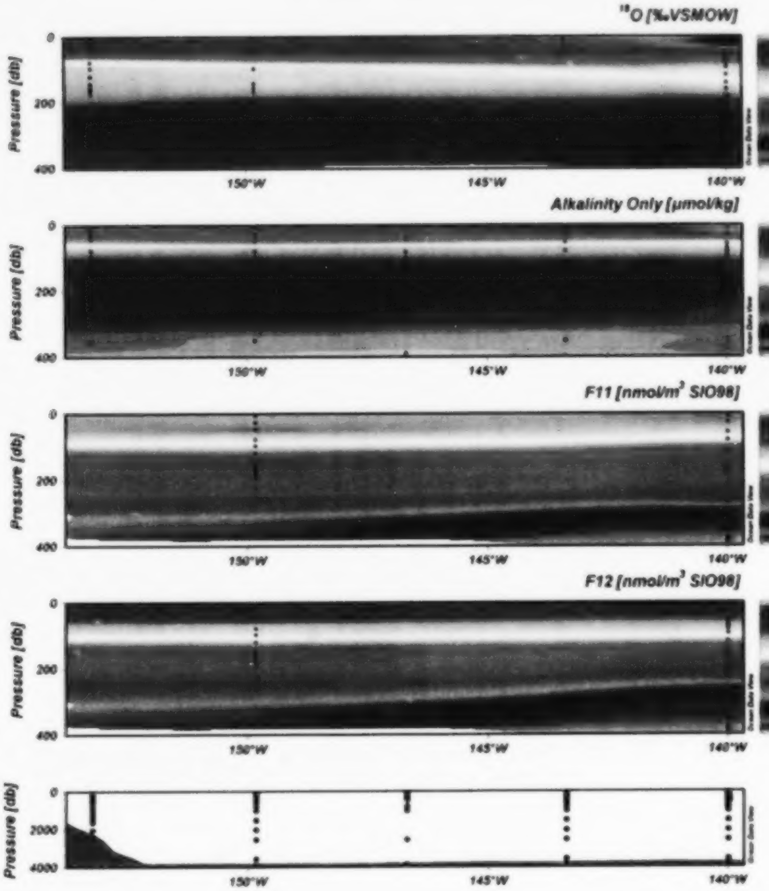
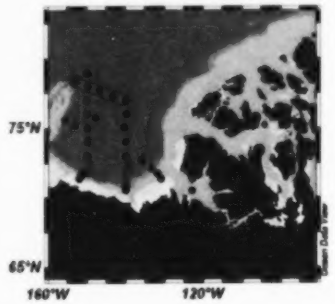
Ocean Data View

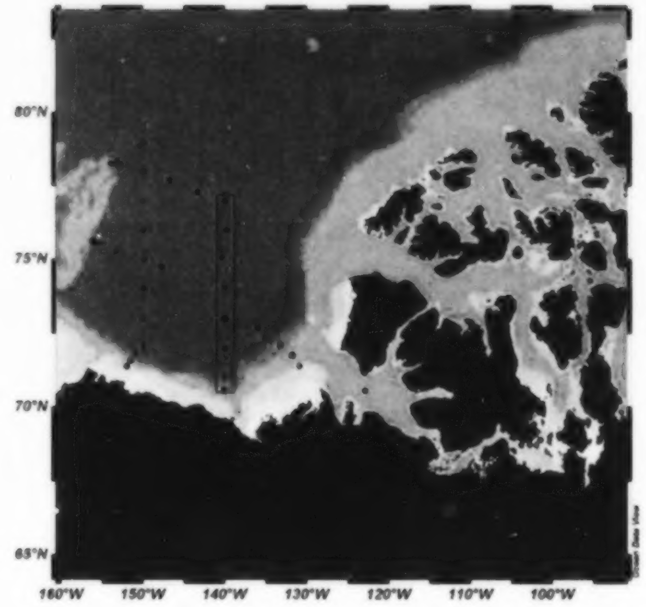
77 to 76°N Section, 0 to 400 db, Chemistry





75°N
65°N
160°W
120°W
Ocean Data View

CTD Map: 140°W Section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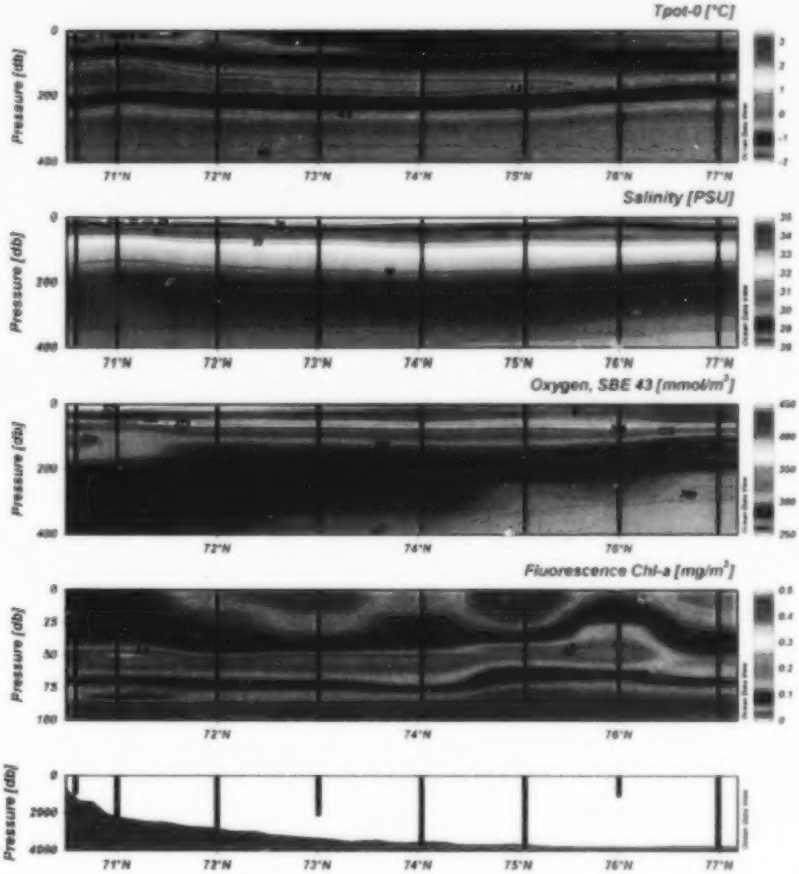
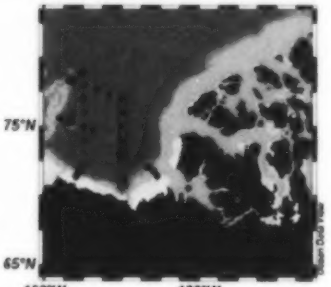
110°W
100°W
Ocean Data View

140°W Section, 0 to 400 db, CTD

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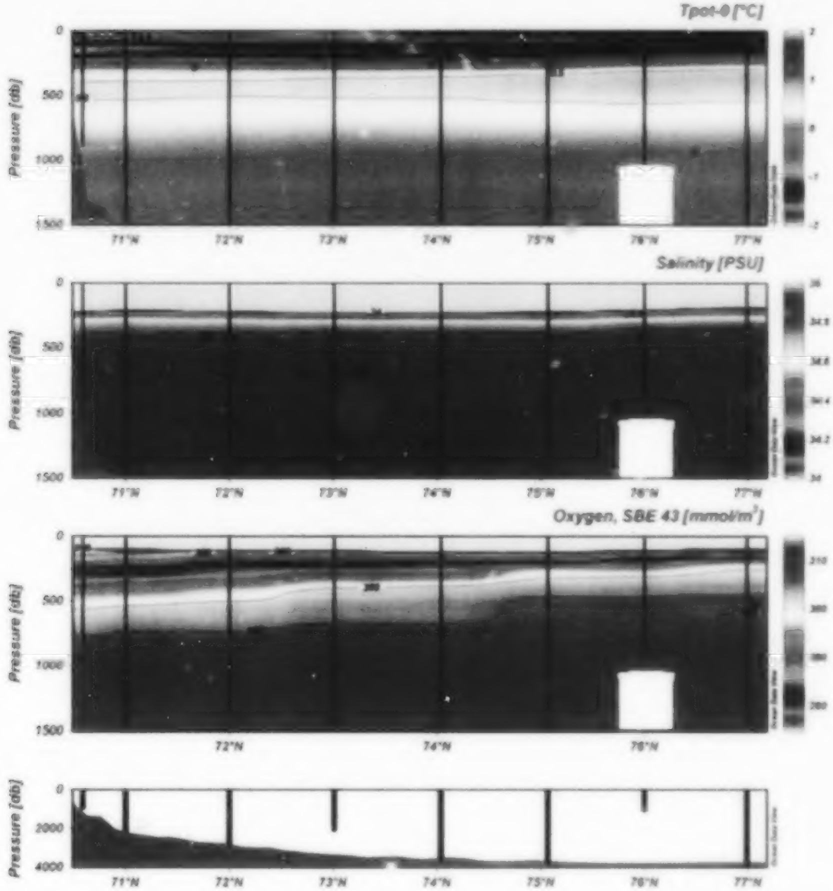
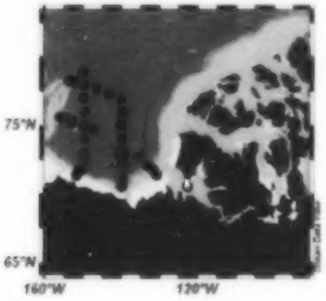
140°W Section, 0 to 1500 db, CTD

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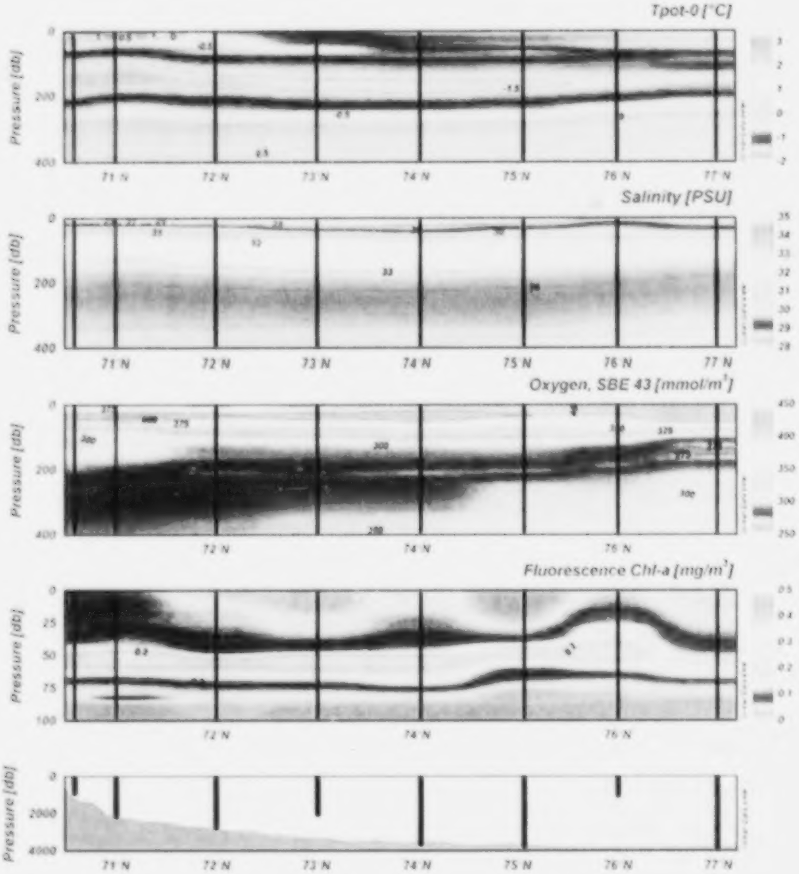
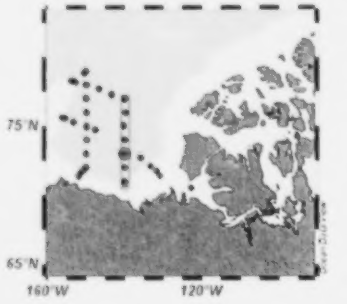
140°W Section, 0 to 400 db, CTD

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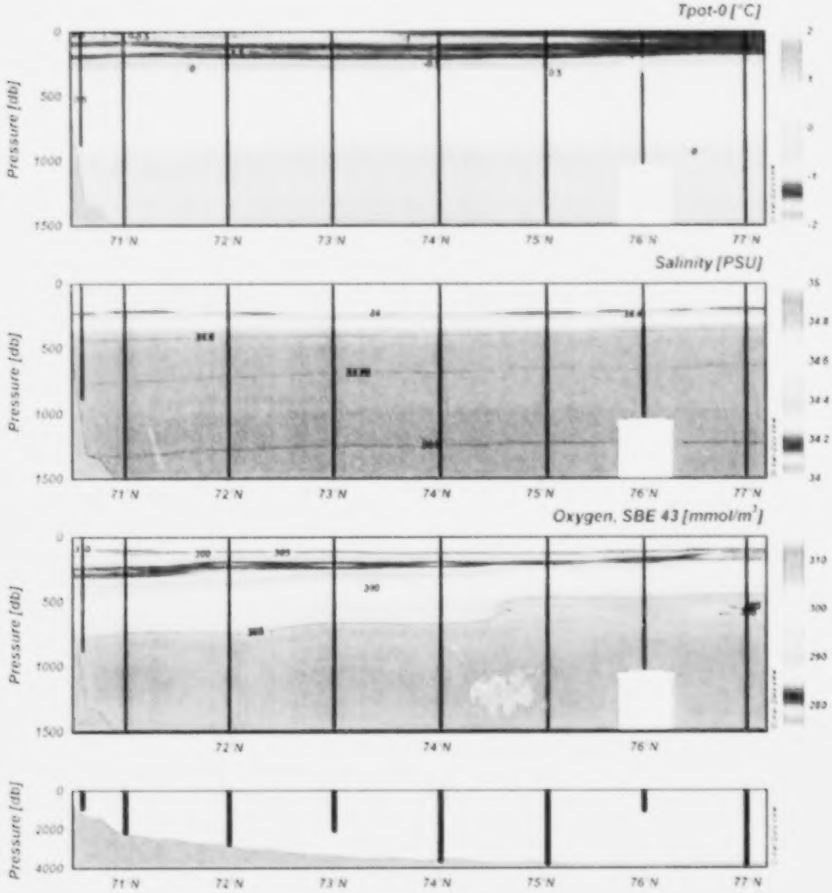
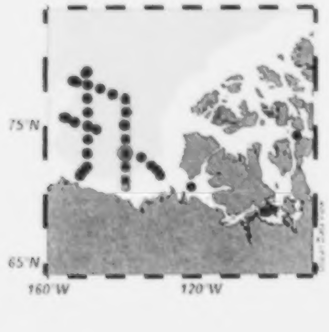
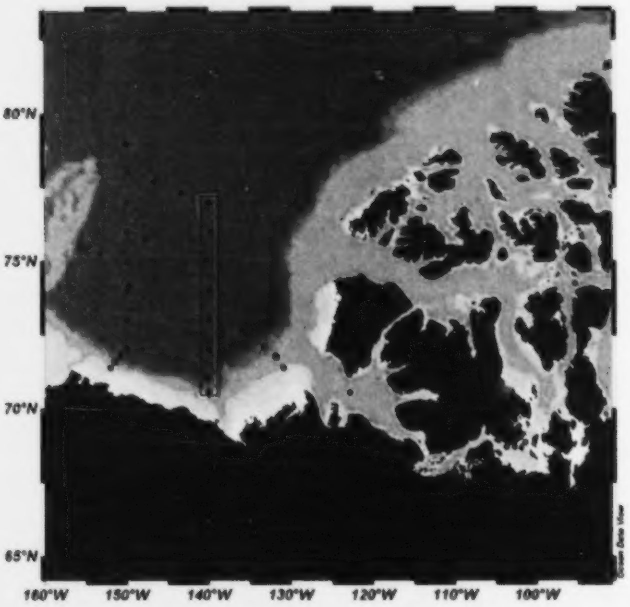
140°W Section, 0 to 1500 db, CTD




75°N
65°N
160°W
120°W

Chemistry Map: 140°W Section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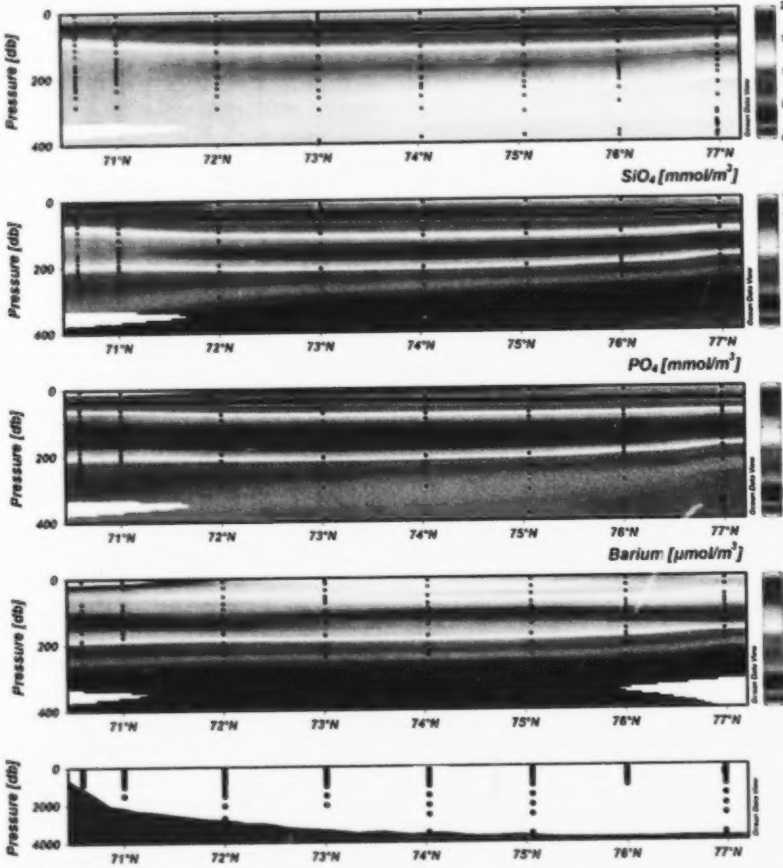
100°W
Ocean Data View

140°W Section, 0 to 400 db, Chemistry



75°N
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160°W
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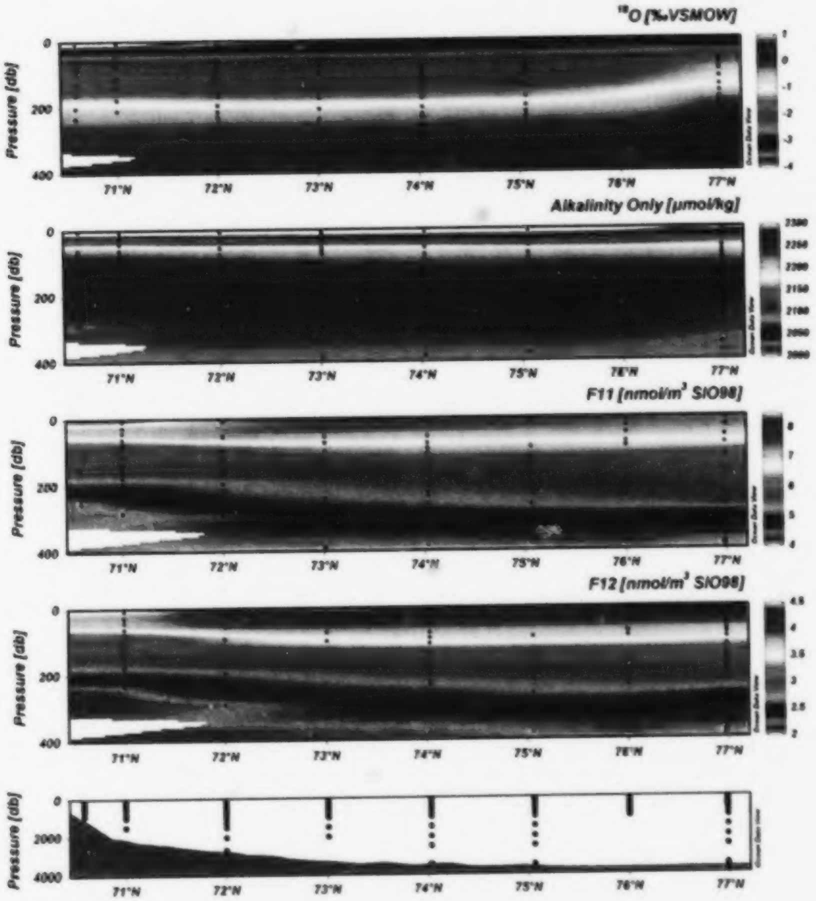
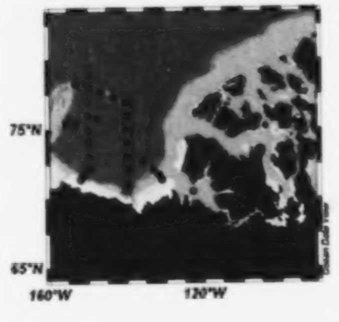
Ocean Data View

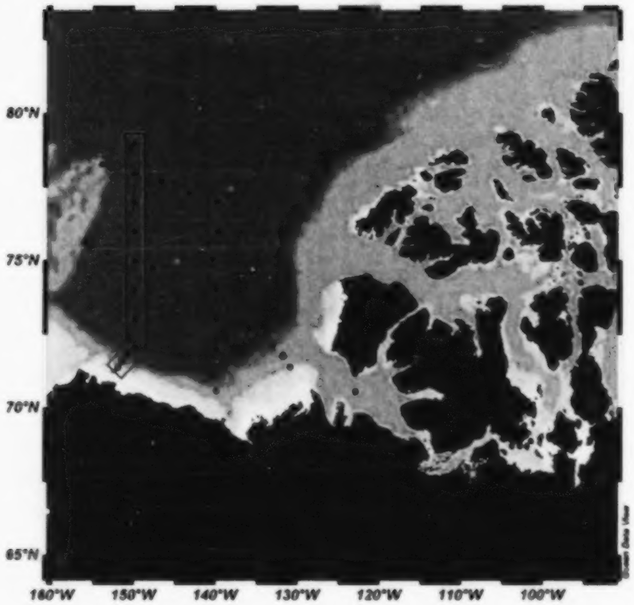
140°W Section, 0 to 400 db, Chemistry





75°N
65°N
160°W
120°W
Ocean Data View

CTD Map: 150°W Section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75°N
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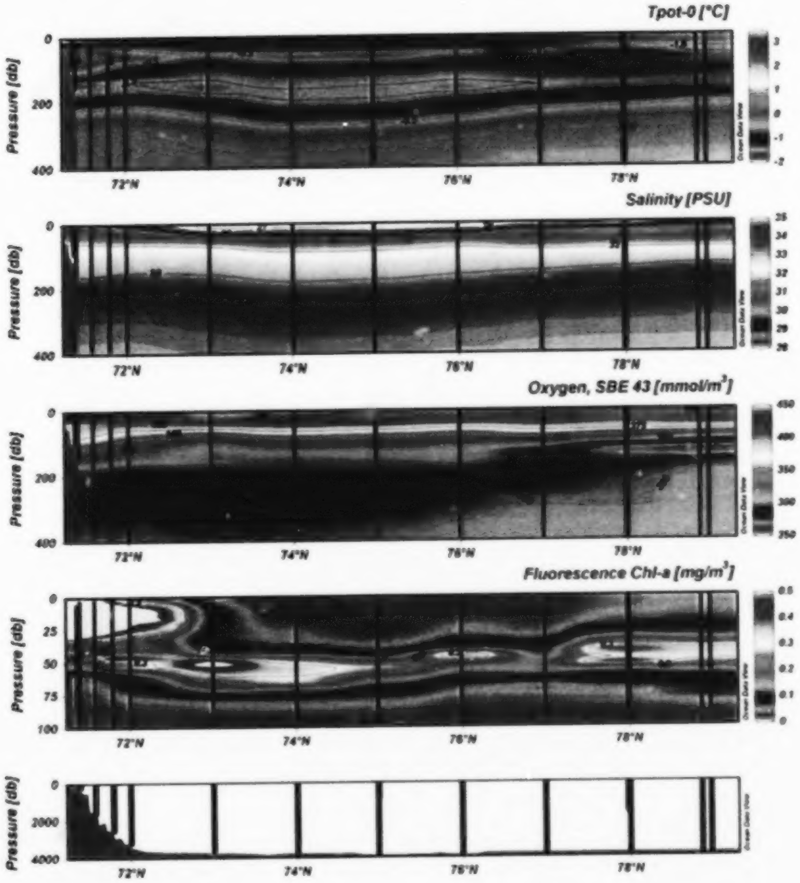
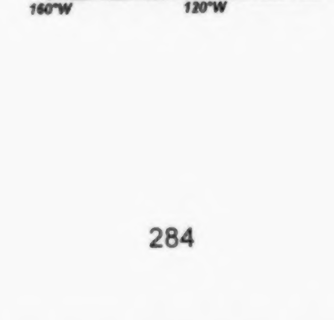
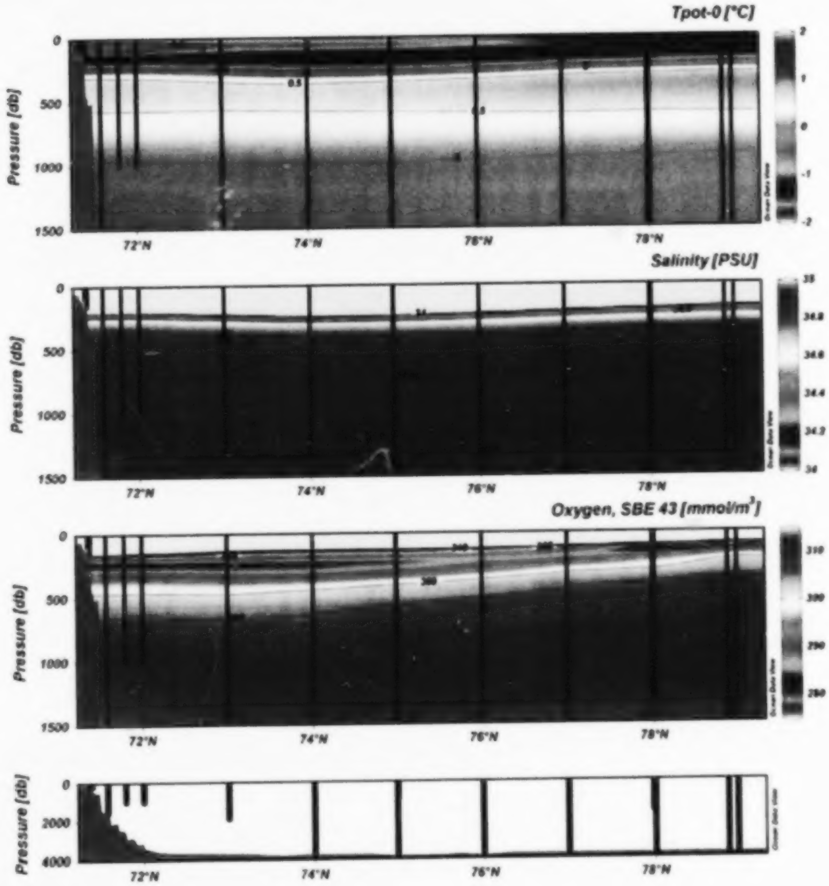
120°W
110°W
100°W
Ocean Data View

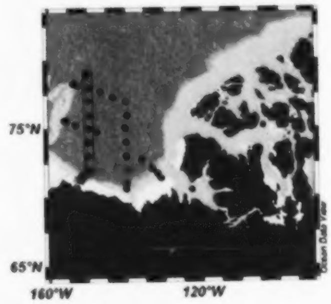
150°W Section, 0 to 400 db, CTD




75°N
65°N
160°W
120°W
Ocean Data View

150°W Section, 0 to 1500 db, CTD




75°N
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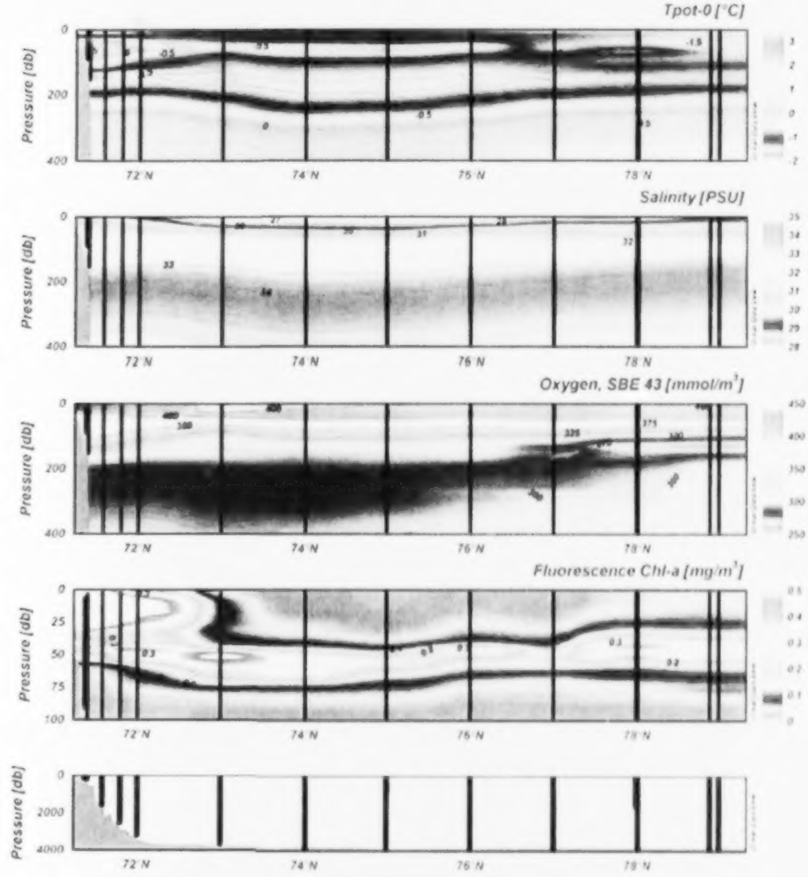
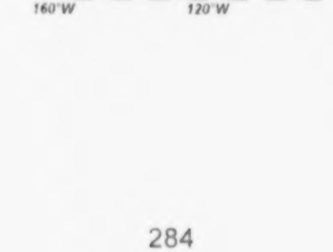
Ocean Data View

150°W Section, 0 to 400 db, CTD




75°N
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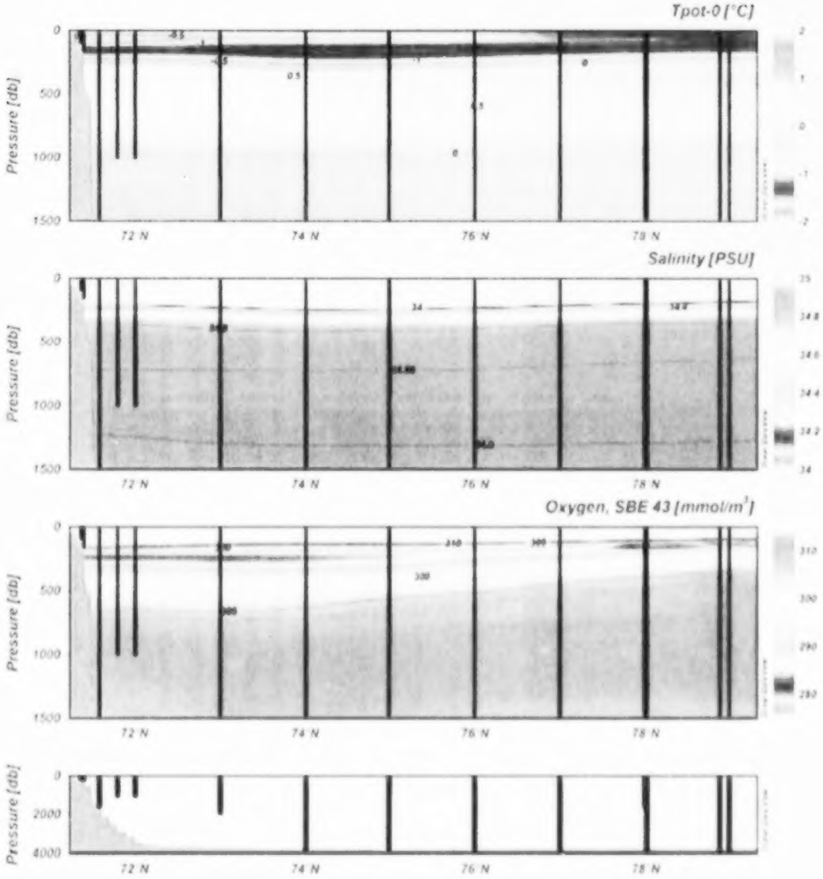
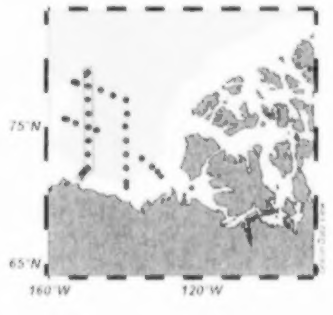
150°W Section, 0 to 1500 db, CTD




75°N
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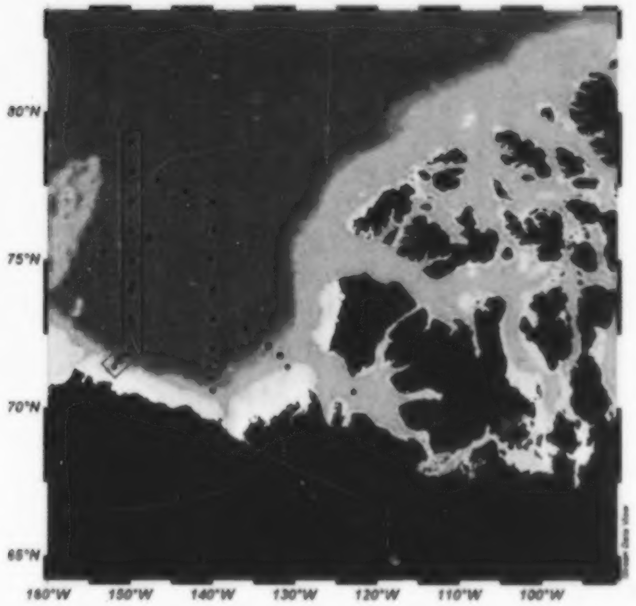
Chemistry Map: 150°W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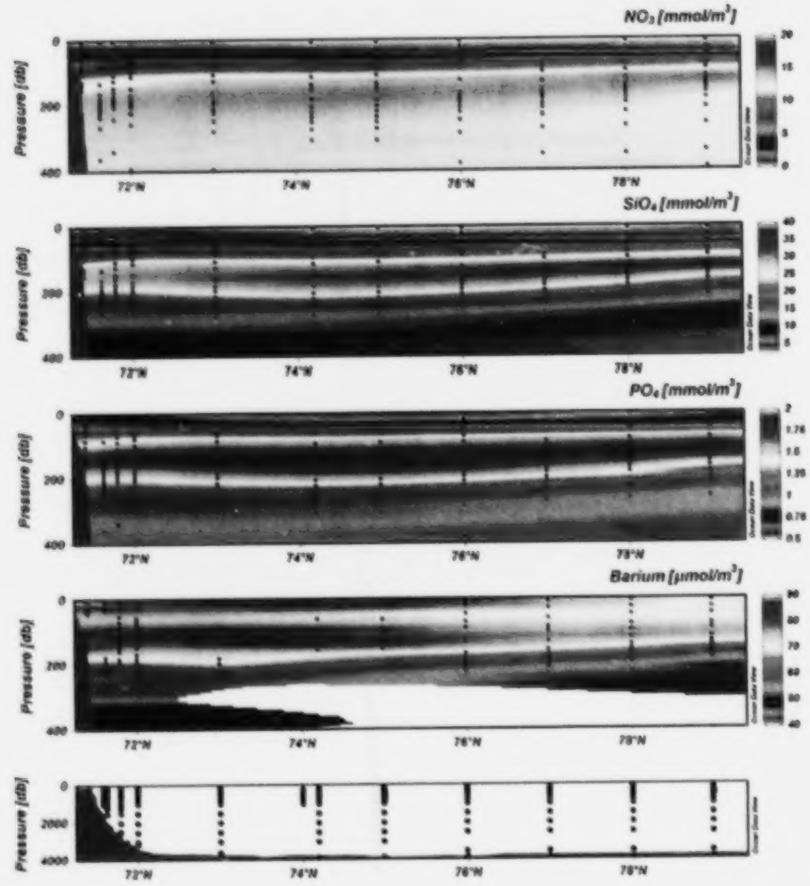
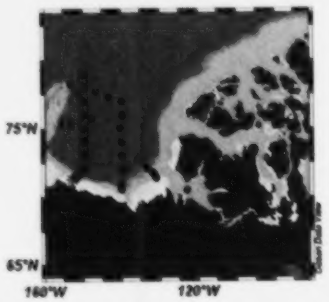
100°W
Ocean Data View

150°W Section, 0 to 400 db, Chemistry

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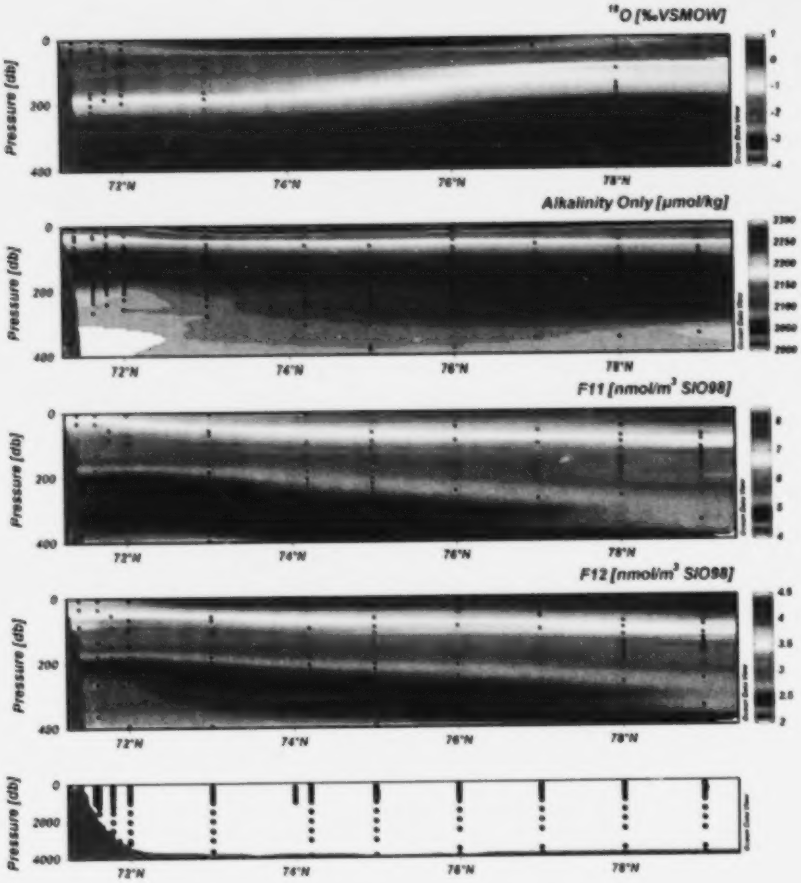
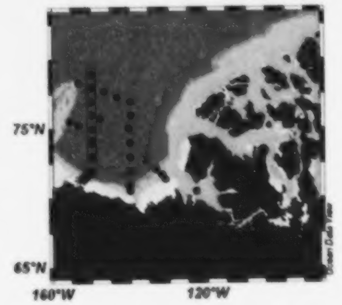
120°W
Ocean Data View

150°W Section, 0 to 400 db, Chemistry





75°N
65°N
160°W
120°W
Ocean Data View

8. LADCP

Waldemar Walczowski, Institute of Oceanology Polish Academy of Sciences, Poland, made ocean current measurements using a Lowered Acoustic Doppler Current Profiler (LADCP). Data were collected on each CTD cast. The self recording RDI, 307.2 kHz device SN 3313 was attached to the rosette frame. The downward-looking LADCP measured currents in 20 depth cells, each cell (bin) 10 m thick. In the vicinity of the bottom, bottom tracking was used. Vertical decent rate of the rosette was always less than 1 m/s. LADCP data were read directly after profiling. Additionally CTD records were used to determine the ship position (from NMEA protocol registered every scan) and LADCP depth (from CTD pressure and time records). LADCP data were processed using LDEO software. 42 LADCP casts were performed (Figure 1).

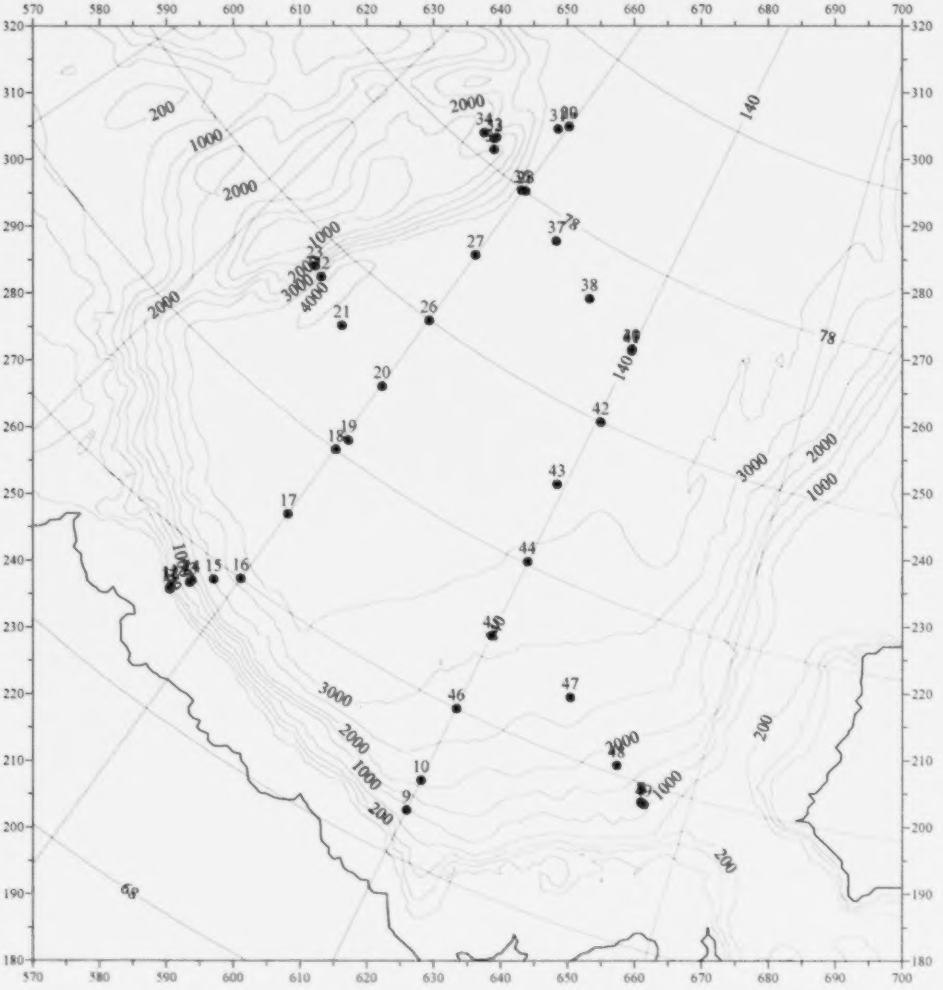

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Figure 1. Positions of LADCP stations during *LSSL* Mission 2005-04.

On the basis of the CTD and LADCP data, quasi-synoptic current fields were obtained in the study area. Calculations were performed several times using various averaging levels. The most reliable data were obtained by averaging currents over layers 50 m thick. Choosing a layer 5 times thicker than that of the registered cell was necessary, due to the very weak signal (backscattering) in deep layers of the Arctic Ocean. Below 2000 m, the amount of useful data dramatically decreased, probably due to lack of particles reflecting sound (Figure 2; Figure 3). The layer between 2500 – 3500 m was especially clear and the measurement error increased accordingly. The signal quality increased slightly over the bottom.

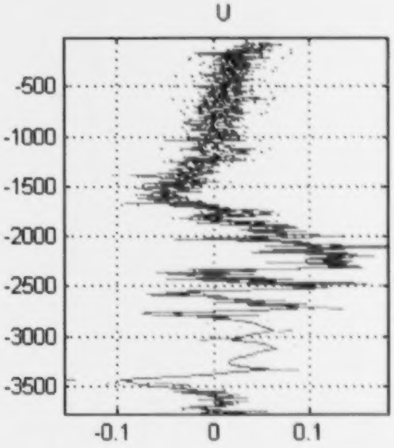


Figure 2. Profile of the current U-component at deep station.

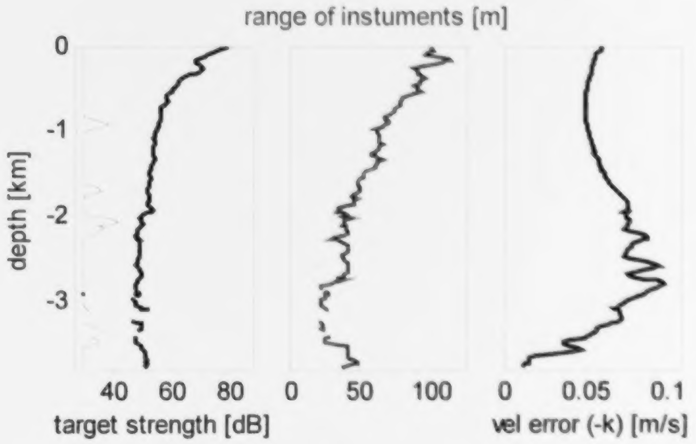
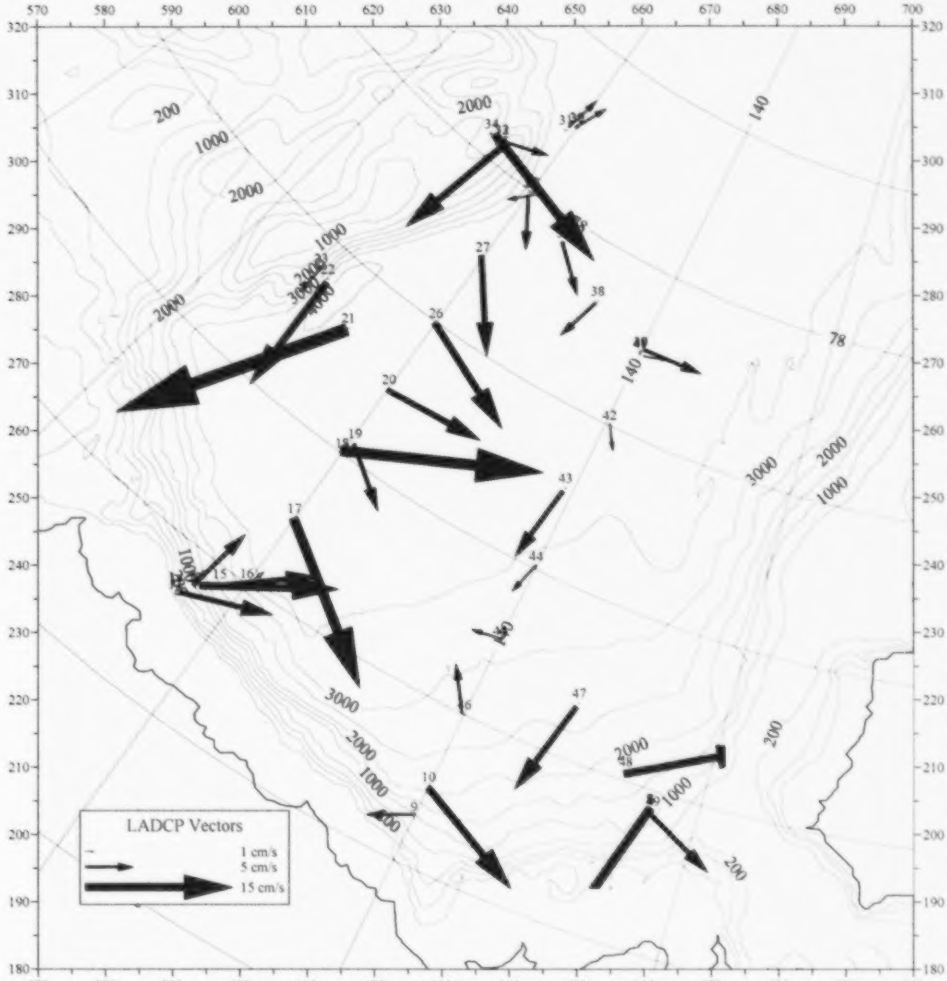


Figure 3. Target strength (backscattering), range of LADCP and measured velocity error.

Results presented were averaged every 50 m. Calculations aimed to limit measured velocity error. The results are preliminary and data will be reprocessed.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250
260
270
280
290
300
310
320
LADCP Vectors
1 cm/s
5 cm/s
15 cm/s
200
1000
2000
3000
140
78

Figure 4. LADCP current vectors at 100 m.

In the upper layer, high current velocities were obtained (Figure 4). At 150°W meridian and west of this meridian, currents reached up to 24 cm/s (station 21). Flow along the eastern border of the Morthwind Ridge was visible. Intensive inflow into the Canada Basin in the Barrow Canyon region was observed. Outflow into the Canadian Archipelago was shown in the south-eastern part of the study area. Possible errors of calculated currents in this layer were large.

Current patterns at 100 m were similar to those at 200 m (Figure 5). Current patterns at 500 and 1000 m were also similar, but the velocities were smaller (Figure 6; Figure 7). Results obtained show high spatial variability of measured currents. Casts repeated in the same place also show high temporal variability of currents in this region. All measurements were conducted within one month, therefore the pictures do not present the 'pure' synoptic view.

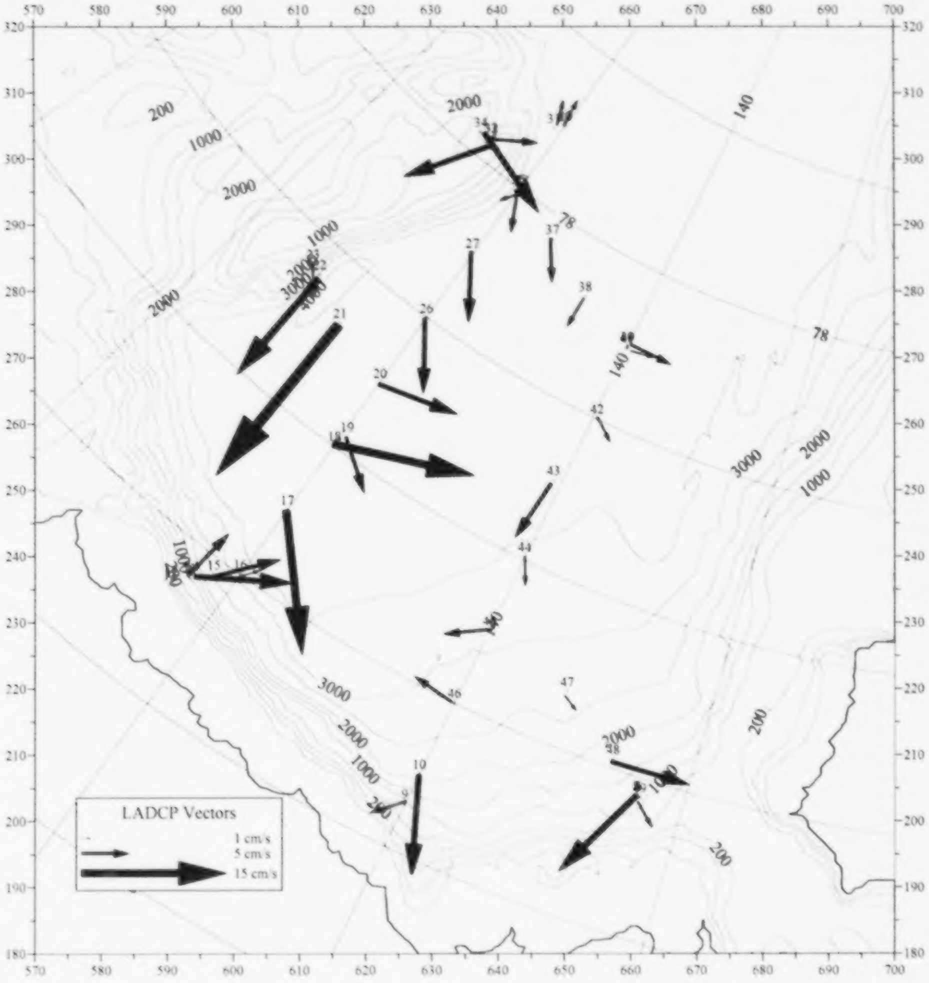
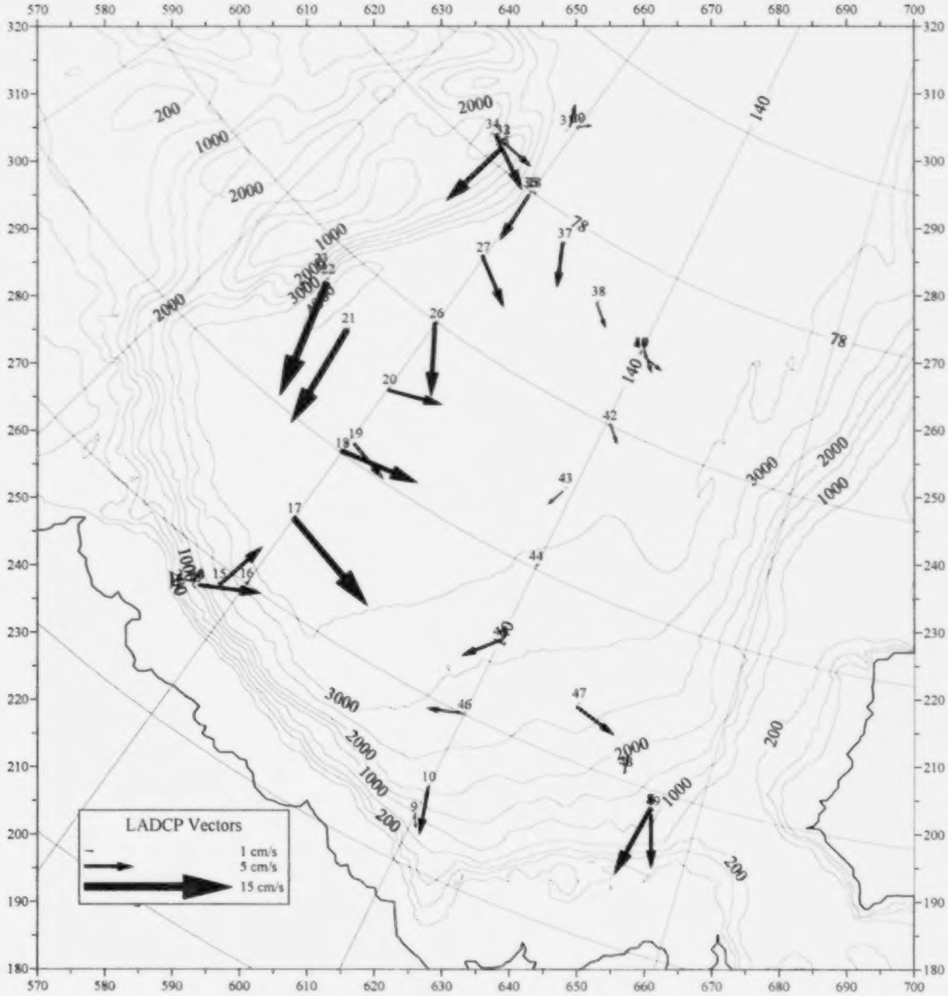


Figure 5. LADCP current vectors at 200 m.


LADCP Vectors
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5 cm/s
15 cm/s
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140
78

Figure 6. LADCP current vectors at 500 m.

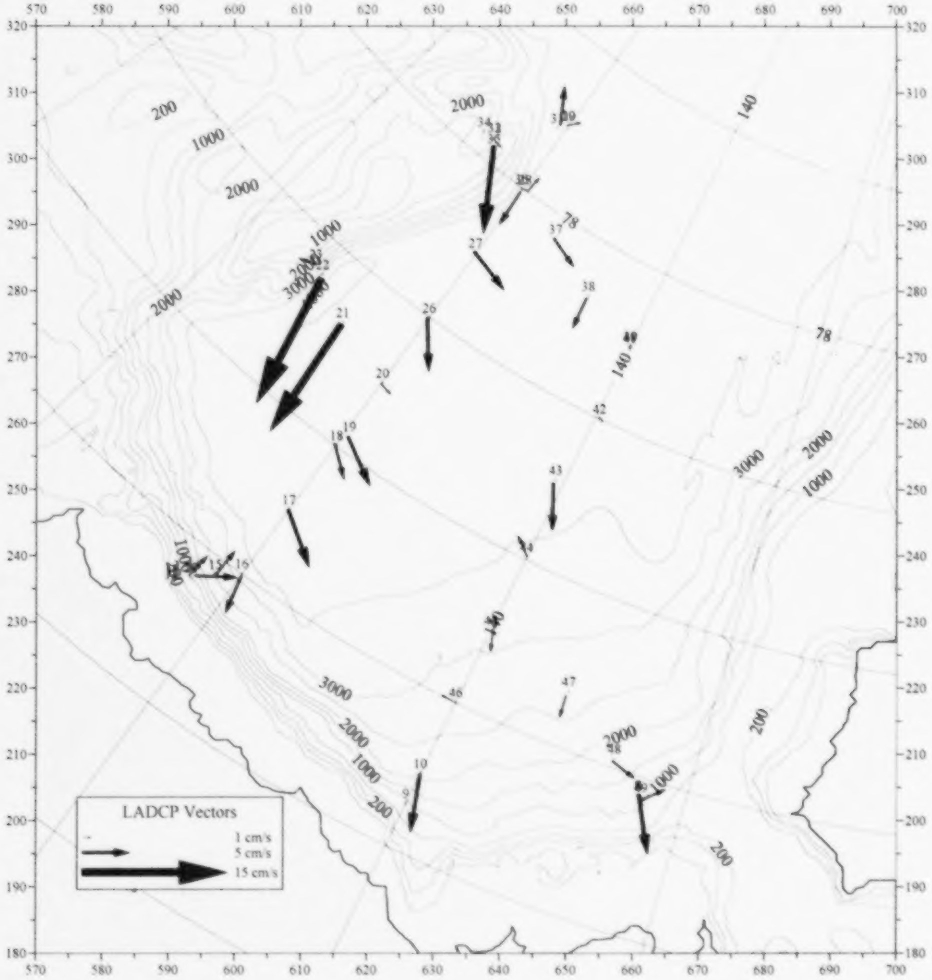


Figure 7. LADCP current vectors at 1000 m.

These results were affected by the high margin of error. The first source of error was the method of measurement – profiling slow currents from a moving platform is not exact; the second source was weak backscattering in deep waters. Also, problems with compass calibration may have caused additional error. The compass was correctly calibrated during the ice station after cast number 31.

The barotropic velocities (mean velocity of the whole water column) were less affected by error. They did not give mass transports or velocities but provided a good picture of whole basin dynamics (Figure 8).

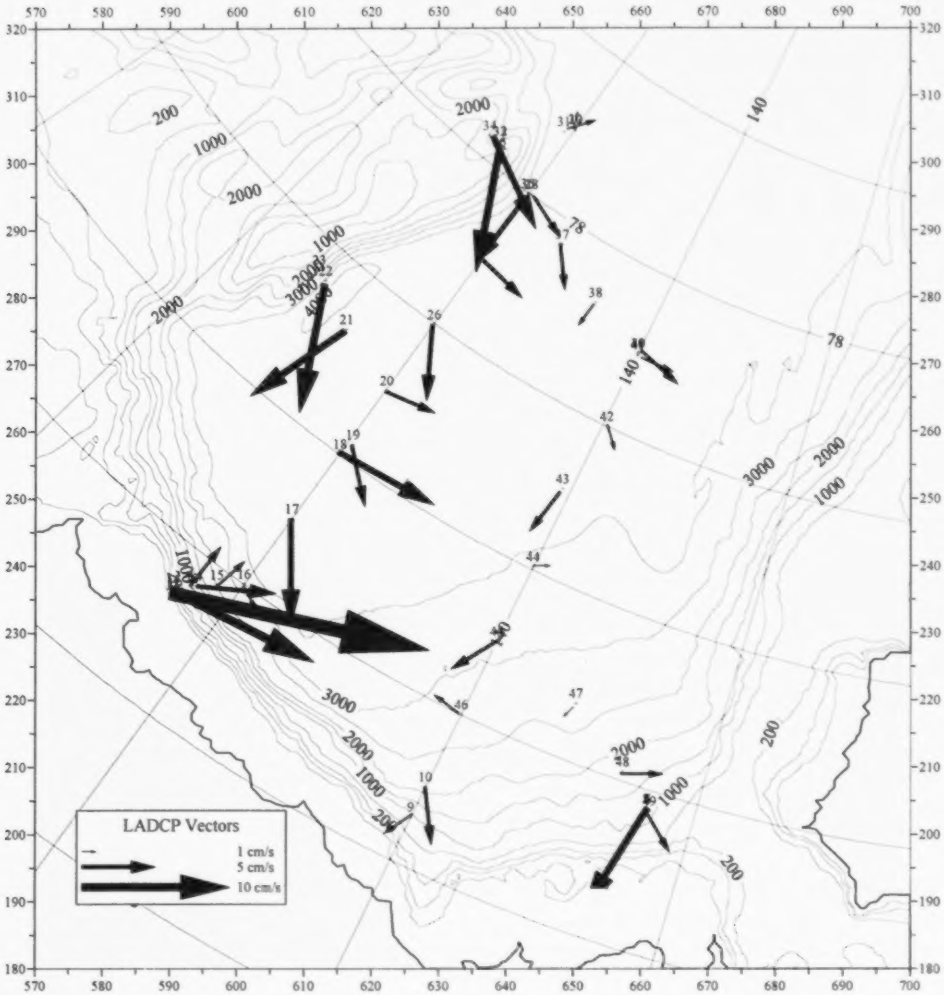

LADCP Vectors
1 cm/s
5 cm/s
10 cm/s
200
1000
2000
3000
4000
78
140

Figure 8. Mean for the whole water column LADCP current vectors.

Limited validation of the results may be performed by comparing the calculated surface currents with the ship drift. Results are presented in Figure 9. LADCP data did not reveal exact surface currents (100 m depth). Also, ship drift was caused by wind. Meteorological data will be used to estimate this factor.

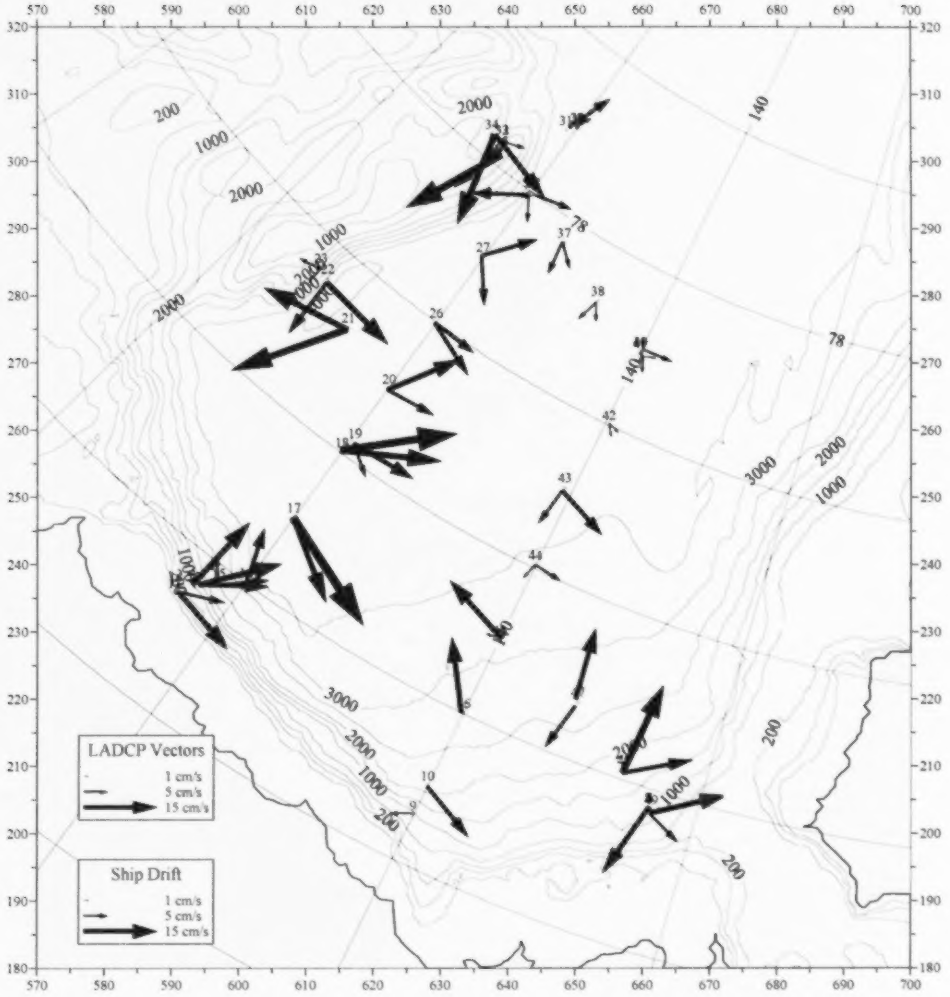
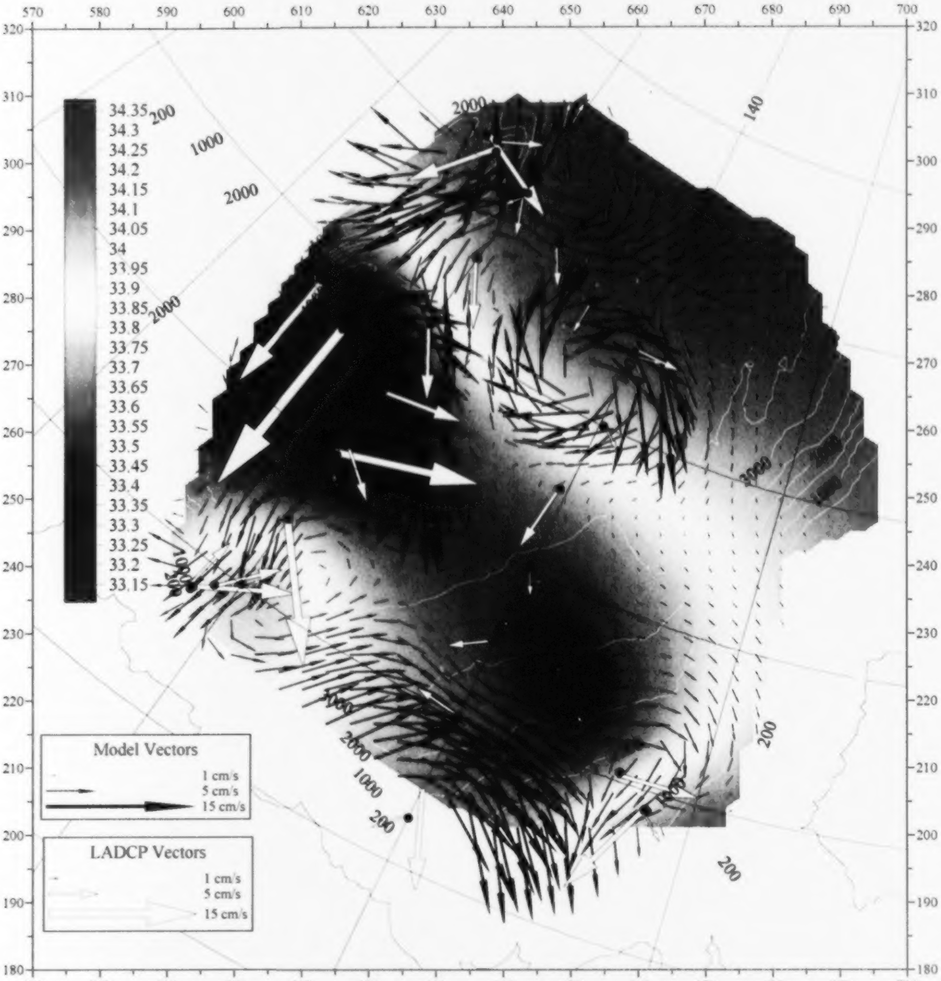

LADCP Vectors
1 cm/s
5 cm/s
15 cm/s
Ship Drift
1 cm/s
5 cm/s
15 cm/s

Figure 9. Mean ship drift velocity during cast (black arrows) and LADCP measured currents at 100 m.

Preliminary calculations of the geostrophic currents were conducted. Mesoscale activity was apparent (Figure 10) and may have influenced the synoptic LADCP observations. However, the horizontal resolution of CTD measurements was too low for proper resolution of the mesoscale structures.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33.35
33.3
33.25
33.2
33.15
200
1000
2000
2000
2000
140
3000
1000
2000
1000
200
200
200
Model Vectors
1 cm/s
5 cm/s
15 cm/s
LADCP Vectors
1 cm/s
5 cm/s
15 cm/s

Figure 10. Salinity field, LADCP and geostropic currents (NML = 1000 m) at 200 m.

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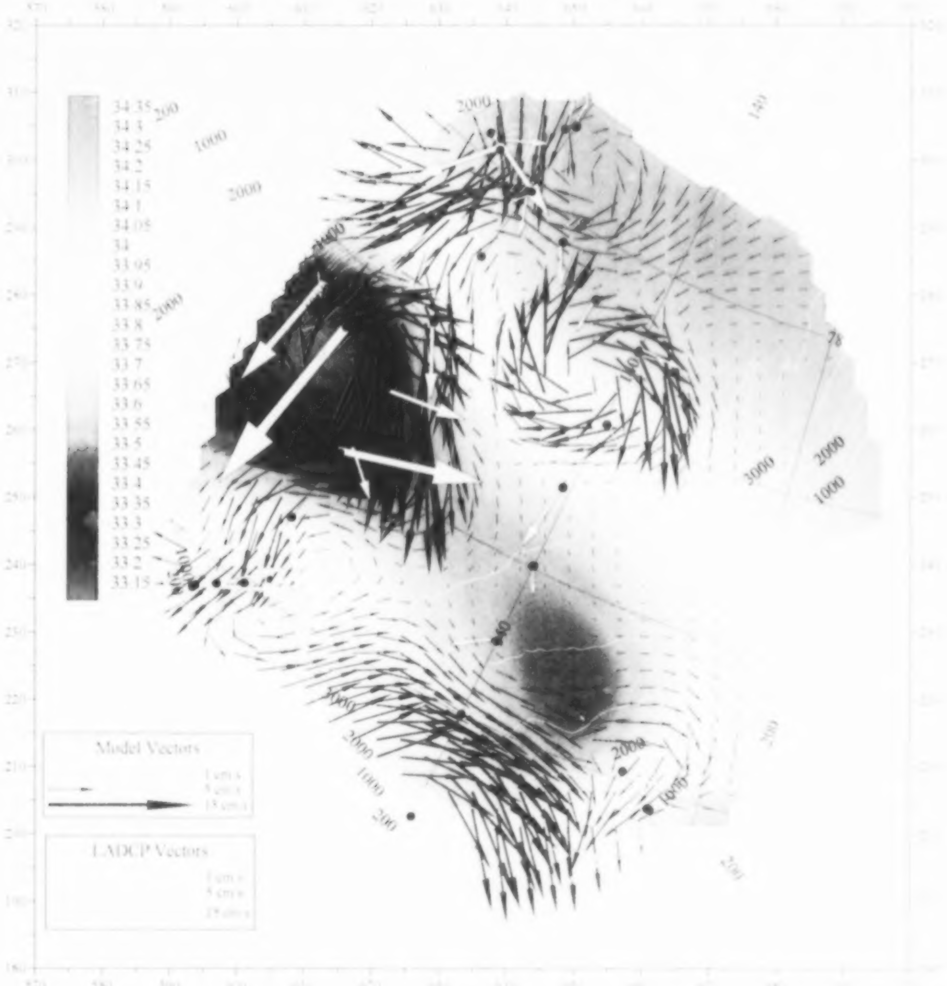
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33.7
33.65
33.6
33.55
33.5
33.45
33.4
33.35
33.3
33.25
33.2
33.15
200
1000
2000
3000
Model Vectors
1 cm/s
5 cm/s
15 cm/s
LADCP Vectors
1 cm/s
5 cm/s
15 cm/s

Figure 10. Salinity field, LADCP and geostropic currents (NML = 1000 m) at 200 m.

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